Identifying the Portfolio Balance Mechanism

Jefferson Duarte and Tarik Umar*

March 21, 2025

Abstract

The Portfolio Balance Mechanism (PBM) theorizes that reducing the supply of U.S. Treasuries (USTs) increases their prices and prompts the creation of similar assets for preferred-habitat investors. We identify the PBM using the suspension of 30-year UST bond auctions between 2002 and 2005. The suspension announcement resulted in a 5.1% daily return on the 30-year UST bond and prompted the issuance of safe, long-term collateralized mortgage obligations (CMOs), created by tranching mortgage pools to meet the demand of life insurers (habitat-preference investors). The heterogeneity of USTs and CMOs and of insurer types results in an unusually clean identification of the PBM.

JEL classification: E43, E52, G21, G22
Keywords: Portfolio balance mechanism, securitization, tranching, preferred habitat, limits to arbitrage, safe assets, financial crisis, quantitative easing

*We thank Marco Grotteria, Zhiguo He, Iryna Kaminska, Eric Richert, Zhaogang Song, Chester Spatt, Athena Tsouderou, Dimitri Vayanos, Nancy Wallace, Xuan Wang, Sean Wilkoff, Luana Zaccaria and participants at the 2025 American Finance Association meeting, 2024 Pre-WFA Summer Real Estate Research Symposium, 11^{th} HEC-McGill Winter Finance Workshop, 2024 Bank of Italy Workshop on Long-term investors' Trends: Theory and Practice, 2024 International Risk Management Conference, 2024 Asia Meeting of the Econometric Society, South Central and Western Asia, 10^{th} International Conference on Sovereign Bond Markets, 2024 Africa Meeting of the Econometric Society, 3^{rd} Spring Finance Workshop in Ischgl, 2023 AREUEA National Conference, 2023 FMA European Conference, 12^{th} Portuguese Finance Conference, 2023 CEAR-MRIC Behavioral Insurance Workshop, and Rice University for helpful comments. We are particularly grateful for the comments and suggestions of Douglas McManus. Duarte (jefferson.duarte@rice.edu) and Umar (Tarik.Umar@rice.edu) are with the Jesse H. Jones School of Business at Rice University.

Empirically identifying the PBM is important, as it is widely recognized as a possible mechanism to explain significant capital market phenomena.[1] Identifying the PBM is challenging because it requires observing changes in investors' portfolios due to UST supply shocks and attributing these changes to a substitution effect. Indeed, UST supply shocks are often accompanied by signals that convey expectations about interest rates. Thus, investors may respond to UST supply shocks due to a signaling mechanism rather than the need to substitute UST bonds with other securities. Hence, identifying the PBM requires studying how UST supply shocks affect investors' portfolios in a setting with falsification tests to attribute shifts to a substitution effect.

We address this identification challenge by capitalizing on the suspension of 30-year UST bond auctions announced on Oct. 31, 2001. During the suspension period, the U.S. Treasury did not issue any nominal USTs with a maturity greater than 10 years. Around this suspension, we examine the extent to which investors, specifically insurance companies, substitute UST bond purchases with newly issued Planned Amortization Class (PAC) CMOs.

Examining insurers' substitution of long-term USTs with PACs during the supply shock helps identify the PBM for several reasons. First, PACs with long average lives and minimal prepayment risk may substitute well for 30-year UST bonds. Agency CMOs have high credit quality, as they are created by tranching cash flows from mortgage pools, known as pass-throughs, which carry credit guarantees from Government-Sponsored Enterprises (GSEs)—Fannie Mae and Freddie Mac—or from the U.S. government in the case of Ginnie Mae pass-throughs (Gorton and Metrick, 2013). By design, PACs have minimal prepayment risk. Hence, agency-PACs have both low credit and prepayment risks, similar to USTs. Second, agency CMOs, especially PACs, are issued regularly in large amounts. PACs comprise about 38% of agency-CMO issuance amounts, and according to SIFMA, CMOs constituted 18% of the total outstanding agency mortgage-related securities between 2002 and 2018. Third, heterogeneity across insurers allows us to examine variations in their responses to the shock, enhancing identification. Life insurers are often considered preferred-habitat in-

[1] Bernanke (2010) suggests that the PBM can explain the impact of QE policies on the real economy. The PBM posits that QE purchases of USTs reduce their net supply, increase their prices, and encourage the issuance of substitute bonds to meet the demand of investors favoring safe long-term bonds, stimulating investment. Before the financial crisis, the PBM suggests that purchases of USTs by the Global Savings Glut (GSG) countries led to a significant increase in securitization to generate safe assets (Bernanke, 2006, 2011).

vestors due to their relatively inelastic demand for long-term bonds (e.g., Koijen, Koulischer, Nguyen, and Yogo, 2017, 2021; Greenwood and Vissing-Jorgensen, 2018). In contrast, Property and Casualty (P&C) insurers are typically regarded as non-preferred-habitat investors for long-term bonds because they have medium-term liabilities (Chen, Sun, Yao, and Yu, 2022). Fourth, the targeted shock to the 30-year UST supply allows us to leverage variation in time-to-maturity for precise identification. Per PBM, different USTs are not perfect substitutes, so the shock to 30-year UST supply pushes habitat-preference investors to hold PACs with long maturities. Thus, we can use life insurers' purchases of PACs with medium average lives (under 10 years) as a control group. Lastly, heterogeneity in the exposure of agency CMOs to prepayment allows for controls and falsification tests to identify the PBM.

We test three PBM-related hypotheses. First, the Preferred Habitat Investors' Substitution hypothesis states that when the excess supply of long-term USTs decreases, habitat-preference investors substitute them with other long-term bonds, such as long-term PACs. Second, the Gap Filling hypothesis states that a decrease in long-term UST supply increases the issuance of long-term bonds created by the private sector to cater to the demand for long-term safe bonds from habitat-preference investors. Third, the Price Reaction hypothesis states that a decrease in long-term UST supply increases the price of these bonds and of substitute long-term bonds such as PACs. We formalize these hypotheses with a model that builds on the gap filling theory in Greenwood, Hanson, and Stein (2010) (GHS), grounded in the PBM assumption as stated by Bernanke (2010) that financial assets are not perfect substitutes for preferred-habitat investors and incorporates limits to arbitrage. Without limits to arbitrage, arbitrageurs can costlessly issue perfect substitutes, resulting in a perfectly elastic supply of long-term bonds and making prices insensitive to changes in supply (Greenwood and Vayanos, 2014; Vayanos and Vila, 2021). And, without frictions, tranching adds no value. In our model, limits to arbitrage render the supply of long-term safe assets not perfectly elastic, allowing mortgage dealers to create value by issuing long-term PAC securities as UST substitutes.

We find support for the Preferred Habitat Investors' Substitution hypothesis. Using a difference-in-difference analysis, we find that life insurers increased purchases of new long-term PACs relative to medium-term PACs during the suspension period. The drop in UST

bond purchases is comparable to the increase in long-term PAC purchases, suggesting a strong substitution. Interestingly, we do not observe the same behavior among P&C insurers (non-preferred habitat investors).[2] These results hold with insurer and time fixed effects and controls for insurer purchases of CMOs with prepayment risk. Thus, the findings are not due to economic conditions, fixed insurer characteristics, or an insurer's time-varying demand for CMOs in general. Consistent with the parallel trend assumption, similar trends in long-term and medium-term PAC purchases are observed both before the 30-year UST auction suspension and after its resumption.

We find support for the Gap Filling hypothesis with another difference-in-difference analysis showing that mortgage dealers created more long-term PACs compared to other CMOs with prepayment risk during the suspension. In contrast, we find no increase in the issuance of long-term agency and corporate bonds. This finding is consistent with Fleming (2000), which notes no corporation matches the U.S. Treasury or the GSEs in issuance size and frequency. Although GSE debt can substitute for USTs in general, agency debt cannot substitute for USTs with 30-years to maturity, as they largely stopped issuing non-callable bonds with a maturity greater than 10 years in 2002.

We find support for the Price Reaction hypothesis. Consistent with Bernanke, Reinhart, and Sack (2004), the daily return difference between 30-year and 10-year USTs was 3.7% on the day the U.S. Treasury announced the suspension of the 30-year UST bond auction (Oct. 31, 2001). We also show a significant reversal of 1.4% when the U.S. Treasury announced the possible resumption of 30-year UST auctions on May 4, 2005. Contrary to the arrival of news about expected interest rates, the announcement did not affect Fed funds futures contracts settling in nine months. Beyond the direct UST price impact, the Oct. 2001 monthly return differential between long- and medium-duration PACs (USTs) was 3.9% (5.7%).

The PBM explains all of our findings, unlike the alternative signaling hypothesis. For example, the 30-year UST auction suspension could signal expected changes in mortgage

[2]Life and P&C insurers invest in agency CMOs. In 1999, life insurers held 7.4% of their fixed income portfolio in agency CMOs, 60% in PAC tranches. P&C insurers held 3.8%, with 65% in PAC tranches. See Table A1. Life USA Holding's 1996 10-K states: "Government agency obligations are predominantly held in the form of PAC CMOs, the most conservative type of CMO issued. These CMOs provide the highest degree of protection against swings in repayments caused by interest rate changes and have virtually no default risk. These securities are well suited to fund the payment of the liabilities they support."

prepayment patterns, affecting the demand for PACs. However, this signaling hypothesis can only explain the increased acquisition of new long-term PACs by life insurers relative to medium-term PACs if the suspension reveals new information about expected prepayments ten years after the announcement. If this were the case, life insurers would also adjust their substantial investments in other long-term CMOs with prepayment risk during the suspension, and P&C insurers would similarly increase their purchases of long-term PACs—both of which contradict our findings. Moreover, signaling also fails to explain the subsequent reversion to the baseline after the resumption of 30-year UST auctions in 2006. This example highlights the advantage of using the targeted 30-year UST supply shock for identification, enabling us to control for such news effects using medium-term USTs and CMOs. This example also highlights the use of CMOs with prepayment risk for falsification tests. Thus, our findings—especially the diverse acquisition behaviors of CMOs by insurers—result in an unambiguous identification of the PBM.

Beyond the suspension event, we find in a sample of nearly 30 years, that long-term PAC creation and long-term PAC demand by life insurers increases relative to long-term CMOs with prepayment risk when the weighted average maturity (WAM) of UST offerings decreases. The results hold when we follow GHS and instrument the UST WAM with total debt to GDP. Additionally, we find no change in the demand for long-term PACs by non-preferred habitat P&C insurers in response to the WAM of UST issuances. This finding addresses any concern that our results are solely driven by variations in an unobservable variable during the suspension period. Moreover, several additional findings support the robustness of our identification of the PBM.[3]

Our findings contribute significantly to the securitization literature. Gennaioli, Shleifer, and Vishny (2012, 2013) formalize the relation between the excess demand for safe assets and tranching volume. In their model, banks create new safe assets by pooling and tranching mortgage portfolios when investor demand for safe assets exceeds supply. The increase in long-term PAC acquisitions by life insurers during the suspension of 30-year UST auctions is direct empirical evidence of this relation between the excess demand for safe assets and

[3]Specifically, in the appendix, we show explore heterogeneity in PAC protection against prepayment. We show that the effect is concentrated in the safest PAC tranches. Second, we find no effect in several placebo periods with similar changes in the fed funds rate but without a shock targeting 30-year UST supply.

tranching volume. Gorton and Metrick (2013) point out that one of the channels by which securitization adds value is the convenience yield channel, where investors pay a premium for certain securities. The convenience yield of long-term agency PACs may stem from preferred-habitat investors' need for safe long-term assets, as hypothesized in the PBM, or from agency CMOs serving as collateral in REPO agreements (Copeland, Martin, and Walker, 2011). We provide evidence of the convenience yield channel, as the price of long-term PACs relative to medium-term PACs increases at the announcement of the UST bond auction suspension, and habitat-preference investors increase PAC purchases during the no-auction period. Tranching may also address a 'lemons problem' when selling portfolios of illiquid assets (DeMarzo, 2005). Our findings cannot be attributed to information frictions, as they do not explain the increased acquisitions of long-term PACs relative to medium-term PACs and variation in UST and PAC prices due to the 30-year auction suspension.

We contribute to the literature on the gap-filling theory of Greenwood, Hanson, and Stein (2010), which posits that the private sector adjusts debt maturity to cater to habitat-preference investors when there is a gap between the supply and demand of safe, long-term bonds. Greenwood, Hanson, and Stein (2010) and Badoer and James (2016) show that corporations extend the maturity of their debt when the UST shortens its debt maturity. Krisnamurthy and Vissing-Jorgensen (2015) show that the financial sector borrows more when government borrowing declines but find no evidence that long-term UST supply crowds out long-term private-sector bond issuance, noting that identifying this maturity effect is challenging without exogenous variation in Treasury maturity structure. We extend this literature in three key ways. First, by leveraging, the targeted shock to 30-year UST supply, our study provides clean identification of the maturity effect. Second, in addition to corporate bonds, we examine the issuance of PACs and agency bonds during the suspension period. We find that mortgage dealers actively filled the gap left by the suspension of 30-year UST auctions. In contrast, agencies ceased 30-year issuances in 2002, and we found no robust evidence that corporations increased their long-term issuances. Under the GHS model framework, the least constrained issuer fills most of the gap. Consequently, our results suggest that mortgage dealers are less constrained than agencies and corporations when responding to supply shocks to 30-year USTs. Third, we move beyond aggregate issuance and

examine the acquisitions of preferred-habitat investors. We show that life insurers directly substitute newly issued long-term PACs for 30-year UST bonds, while non-preferred-habitat investors (P&C insurers) do not. Combined with the increase in long-term PAC issuance, this provides clear identification of catering to habitat-preference investors to fill the gap left by the UST supply shock.

Much of the QE literature examines the impact of supply shocks on UST prices. This literature is largely supported by models such as Greenwood and Vayanos (2014) and Vayanos and Vila (2021), in which limits to arbitrage create a relationship between supply shocks and bond yields. Our model also builds on these same limits to arbitrage. Using a perfect foresight calculation, we estimate that the yield shock due to the decrease on the 30-year UST supply implies a multiplier of 0.52 basis points (bp) per billion-dollar reduction in supply. This multiplier closely aligns with Bernanke, Reinhart, and Sack (2004), who estimate 0.66 bp per billion-dollar shock. This similarity is notable, as both studies examine different shocks in the same period, suggesting that variations in multiplier estimates across the literature may stem from time-varying factors.[4] For instance, D'Amico and King (2013) highlight that multipliers are larger during periods of market stress when arbitrageurs' risk penalties are elevated. During the period examined in both our study and Bernanke, Reinhart, and Sack (2004), marginal investors in U.S. Treasuries were likely highly inelastic due to the suspension occurring after Treasury bond buybacks and budget surpluses. As a result, investors with elastic demand likely substituted UST bonds with other bonds in the years leading up to the suspension of 30-year UST auctions.[5]

The PBM links the pre-crisis surge in securitization to a growing demand for safe assets from GSG countries, as discussed by Bernanke (2011). Empirical evidence shows regulatory arbitrage and information frictions contributed to the pre-crisis rise in securitization (e.g., Acharya, Schnabl, and Suarez, 2013; Begley and Purnanandam, 2016),[6] while evidence link-

[4] Bernanke, Reinhart, and Sack (2004) estimate a multiplier based on UST purchases made by the Japanese monetary authority from Jan. 3, 2000, to Mar. 3, 2004, focusing on USTs with maturities of 10 years or less.

[5] We also contribute to the QE literature by examining the portfolio balance mechanism among inelastic-demand investors (life insurers) in response to a long-term (four-year) supply shock. In contrast, most QE studies rely on high-frequency event studies—primarily to mitigate endogeneity concerns—and focus on elastic-demand investors, such as mutual funds (Selgrad, 2023; Breckenfelder and De Falco, 2023).

[6] A driver for increased tranching could be regulatory arbitrage, where tranching generates highly rated securities subject to more favorable capital requirements. Information frictions could also explain tranching,

ing the surge in securitization to the PBM mainly shows a correlation between the foreign demand for safe US assets and the issuance of AAA-rated private label securities (Bernanke, Bertaut, DeMarco, and Kamin, 2011; Bertaut, DeMarco, Kamin, and Tryon, 2012).[7] Our estimated multiplier of 0.52 for 30-year USTs supports the high multiplier of 0.66 reported in Bernanke, Reinhart, and Sack (2004) for three-, five-, and ten-year USTs. Together, these findings indicate that shocks across the maturity spectrum had significant price effects in the early 2000s, suggesting substantial price increases stemming from heightened demand for safe assets by GSG countries, which in turn motivated a record issuance of AAA securities by the private sector. Naturally, our findings do not rule out that pre-crisis tranching increased due to information frictions or regulatory arbitrage but support the idea that the PBM played a role.

Section 1 briefly describes different types of CMOs; Section 2 develops the tested hypotheses; Section 3 describes the shock to the supply of the 30-year UST bond; Section 4 describes the identification strategy; Section 5 describes the data; Section 6 describes the empirics; and Section 7 concludes.

1 CMOs

Understanding our identification strategy requires knowledge of the differences between the CMOs in our analysis, which mainly uses PACs. PACs are agency-CMOs with predetermined principal payments, given the prepayment speeds of the underlying pass-through stay within "PAC bands", typically defined by PSA standard, which serves as a basic metric to model prepayment speed scenarios for mortgage pass-throughs.[8] Panel A of Figure 1 shows the cash flows of a PAC with bands from 100% PSA to 250% PSA. The humped-shaped lines indicate the principal payments for fast (250% PSA) and slow (100% PSA) prepayment scenarios. The PAC's promised principal is the minimum amount between these fast and slow prepayment scenarios. Panel A also illustrates that a PAC is paired with a Support (SUP) tranche, which

suggesting the pre-crisis surge in securitization was due to increased mortgage supply rather than demand for safe assets.

[7] Tranching non-agency loan pools (private labels) creates tranches with varying credit ratings, while tranching agency pass-throughs results in tranches with identical credit risk due to credit guarantees.

[8] See Appendix A.1 and Duarte and McManus (2016) for details on the PSA standard.

receives remaining cash flows from the mortgage pool after PAC payments. The SUP tranche bears a larger portion of prepayment risk. In the 250% PSA scenario, the SUP tranche gets principal payments sooner, while in the 100% PSA, it receives them later.

[Insert Figure 1 Here]

PAC tranches are typically structured sequentially, directing principal payments to each tranche until it is fully amortized before proceeding to the next. This approach results in varying average lifespans across tranches. Figure 1, Panel B illustrates cash flows of three PACs with varying weighted average lives and bands from 100% PSA to 250% PSA. The short-term PAC is paid off in 60 months, the second from months 61 to 120, and the long-term from months 121 to 360.

We also analyze Sequential (SEQ) CMOs, the second most common CMO type. Figure 1, Panels C and D, illustrate cash flows for three SEQs with varying weighted average lives under different prepayment scenarios. Unlike PACs (Panel B), SEQs lack a companion SUP tranche, exposing them to prepayment risk. This is evident in Panel C, where principal payments accelerate at 250% PSA compared to 100% PSA in Panel D. Consequently, SEQs are less ideal substitutes for long-term UST bonds, which do not face prepayment risk.

Habitat-preference investors, like life insurers, favor PACs for their stability and predictable cash flows, though SEQs are also common in their portfolios.[9] In contrast, investors with lower prepayment risk aversion, such as hedge funds, prefer SUP tranches (Fabozzi and Ramsey, 1999). Mortgage dealers structure agency CMO securities to match investors' varying risk tolerances and may hold SUP tranches when advantageous.

2 Hypotheses Development

We formalize three PBM-related hypotheses using a model adapted from GHS, incorporating a mortgage dealer and relaxing the assumption that investors' demand for long-term bonds is perfectly inelastic to allow for non-preferred habitat investors, like P&C insurers. Like

[9]For example, the Travelers Group Inc. 1997 10-K highlights life insurers' preference for prepayment-protected CMO tranches, particularly PACs, due to their stable cash flows. While they may invest in other tranches after careful risk assessment, they avoid residual interests in CMOs.

GHS, we assume a three-period setting where the first-period short-term interest rate is r_1, and the second-period rate is r_2 with mean μ_r and variance σ_r^2.

Two investors hold bonds maturing at $t = 3$, differing only in their demand elasticities. Their net demand, after accounting for government supply, is given by:

$$Z^i = \frac{1}{2}\Big[\alpha^i\Big(\tfrac{1}{P} - (1+r_1)(1+\mu_r)\Big) \; - \; g\Big] \tag{1}$$

where $\alpha^i \geq 0$ represents the demand elasticity of investor i, and $g \leq 0$ is a constant. Demand for long-term bonds decreases with price (P) and rises with excess return, $\frac{1}{P} - (1+r_1)(1+\mu_r)$. Preferred-habitat investors ($i = PH$) have less price-elastic demand than non-preferred-habitat investors ($\alpha^{PH} < \alpha^{NPH}$). The constant $\frac{1}{2}$ ensures consistency with GHS: when $\alpha^{PH} = \alpha^{NPH} = 0$, both investors are fully inelastic with demand $-g/2$, matching GHS, where g denotes net bond issuance after inelastic preferred-habitat demand. Furthermore, in this scenario and in the absence of a mortgage dealer, our model solutions are identical to those in the special case of the GHS model without corporations.

Similar to GHS, our model includes a yield curve arbitrageur who meets the excess demand for long-term bonds by selling h dollars of long-term bonds at price P and reinvesting the proceeds at the short-term interest rate. The arbitrageur maximizes mean-variance utility of terminal wealth:

$$\max_h h\left[(1+r_1)(1+\mu_r) - \frac{1}{P}\right] - \frac{h^2}{2}\eta_h \tag{2}$$

where $\eta_h = (1+r_1)^2\sigma_r^2/\lambda$ represents the risk penalty of the yield curve strategy, and λ is the yield curve arbitrageur's risk tolerance.

The mortgage dealer meets the excess demand from preferred-habitat investors by issuing f dollars of non-prepayable long-term bonds maturing at $t = 3$ to finance mortgage pass-through securities, which can be prepaid. These bonds, termed long-term PACs, resemble actual PACs with minimal prepayment exposure and are collateralized by mortgage pass-throughs. Homeowners borrow via fixed-rate mortgages maturing at $t = 3$ and can prepay at $t = 2$ without penalty. The mortgage rate is set exogenously in the pass-through market. Preferred-habitat investors avoid mortgage pass-throughs due to prepayment risk. Let M_I be the value at $t = 3$ of interest payments on \$1 of mortgage principal from $t = 1$ to $t = 3$, with mean μ_M and variance σ_M^2. Let P be the price at $t = 1$ of the PAC maturing at $t = 3$. Since

M_I is subject to prepayment risk while P is not, the mortgage dealer assumes prepayment risk.[10] The mortgage dealer maximizes mean-variance utility of terminal wealth:

$$\max_f f(1+\mu_M-\frac{1}{P})-\frac{f^2}{2}\eta_f \tag{3}$$

where $\eta_f=\sigma_M^2/\theta$ represents the risk penalty, and θ is the dealer's risk tolerance.

When the mortgage dealer and arbitrageur are risk-averse ($\eta_f>0$, $\eta_h>0$) and non-preferred-habitat investor demand is not perfectly elastic ($\alpha^{NPH}<\infty$), the model generates the three PBM hypotheses:[11]

Hypothesis 1: Preferred Habitat Investors' Substitution *When the excess supply of long-term USTs decreases, habitat-preference investors, such as life insurers, substitute them with other long-term bonds, such as long-term PACs.*

Preferred-habitat investors substitute UST bonds more than non-preferred-habitat investors. The difference in long-term bond purchases between the two groups is:

$$Z^{PH}-Z^{NPH} \;=\; -\frac{g}{2}\,\frac{(\alpha^{NPH}-\alpha^{PH})\,\eta_f\,\eta_h}{\eta_f+\eta_h\;+\;\overline{\alpha}\,\eta_f\,\eta_h}. \tag{4}$$

where $\overline{\alpha}$ is the mean of α^{PH} and α^{NPH}. With $g<0$ and $\alpha^{NPH}>\alpha^{PH}$, this implies that preferred-habitat investors buy more long-term bonds than non-preferred-habitat investors.

Hypothesis 2: Gap Filling *The issuance of long-term bonds by the private sector increases when the excess supply of long-term USTs decreases, fulfilling the demand for long-term bonds from habitat-preference investors.*

The model explains the rationale for tranching. The amount of long-term bonds issued by the private sector (mortgage dealers and yield-curve arbitrageurs) is:

$$f^*=-\frac{\eta_h}{\eta_f+\eta_h+\overline{\alpha}\eta_f\eta_h}g,\quad h^*=-\frac{\eta_f}{\eta_f+\eta_h+\overline{\alpha}\eta_f\eta_h}g \tag{5}$$

[10] In the model, the long-term PACs do not have PAC bands, implying that the mortgage dealers are completely assuming the risk of prepayment and not leaving any risk to the PAC buyers. Moreover, by assuming this prepayment risk, the dealers emulate the roles played by dealers and hedge funds in reality.

[11] If $\alpha^{NPH}\to\infty$, NPH investor demand becomes perfectly elastic, supplying $-g/2$ bonds to preferred-habitat investors, eliminating the need for risk-averse yield curve arbitrageurs and mortgage dealers. We assume prepayment risk is not priced in pass-throughs. See Appendix A.2 for details.

Tranching is a blunt violation of the Modigliani and Miller (MM) proposition.[12] Equation 5 shows that when there are no limits to yield curve arbitrage ($\eta_h = 0$), the yield curve arbitrageur fully absorbs excess bond supply shocks, eliminating the need for tranching ($f^* = 0$), and MM holds. However, with limits to arbitrage ($\eta_h > 0$), mortgage dealers help absorb negative supply shocks by issuing long-term PACs. Hence, tranching arises from arbitrage limits and investors' inelastic demand for securities (Davidson, Sanders, Wolff, and Ching, 2008), such as habitat preferences for long-term bonds (e.g., Culbertson, 1957; Modigliani and Sutch, 1966).

Although preferred-habitat investors view yield-curve arbitrageur bonds and PACs as substitutes, when the excess supply of long-term USTs decreases, they may substitute more with PACs than with bonds issued by the yield-curve arbitrageur. This occurs due to the differing constraints on mortgage dealers and yield-curve arbitrageurs. Equation 5 shows that the less constrained entity—whether the arbitrageur or the mortgage dealer—supplies most long-term bonds, a result also found in GHS. In their model, corporations adjust debt maturity based on capital structure constraints (e.g., Myers, 1977; Barclay and Smith, 1995; Harford, Klasa, and Maxwell, 2014). When safe long-term bond supply declines, corporations deviate from target maturity to fill the gap, depending on their constraints relative to the yield curve arbitrageur. Hence, whether preferred-habitat investors substitute long-term USTs with corporate bonds, PACs, or agency debt remains an open empirical question.

Mortgage dealers may be particularly suited to offset a decline in long-term UST supply. Unlike corporations or agencies, they face no fixed maturity constraints, only risk aversion, similar to arbitrageurs. This aligns with the view that dealers primarily structure CMOs to cater to buyers. The iterative design process reflects this: dealers present hypothetical agency CMO structures and pricing to assess demand, refining proposals until the final structure date when collateral and cash flow rules are set.

Hypothesis 3: Price Reaction. *The price of long-term bonds, such as long-term USTs and long-term PACs, increases in response to negative supply shocks in long-term UST bonds.*

[12] CMOs, structured as Real Estate Mortgage Investment Conduits (REMICs), offer no corporate tax advantages (Gorton and Metrick, 2013).

The two-period expected excess return of the long-term bond is:

$$\frac{1}{P} - (1 + r_1)(1 + \mu_r) = \frac{\eta_f \eta_h}{\eta_f + \eta_h + \overline{\alpha}\eta_f \eta_h} g \tag{6}$$

The price of the long-term bond in Equation 6 responds to shocks in its excess supply. Specifically, Equation 6 implies that the multiplier measuring the reaction of the two-period bond excess return to a shock in UST bond supply is given by $\frac{\eta_f \eta_h}{\eta_f + \eta_h + \overline{\alpha}\eta_f \eta_h}$.

Unlike models without limits to arbitrage, this multiplier is potentially different from zero. For instance, when the yield curve arbitrageur is risk-neutral ($\eta_h = 0$), eliminating constraints on yield curve arbitrage, the price of the long-term bond—as specified in Equation 6—becomes independent of its excess supply, consistent with the expectation hypothesis. In contrast, in models that incorporate limits to arbitrage—such as Greenwood and Vayanos (2014) and Vayanos and Vila (2021)—bond yields respond to bond supply shocks.

3 Description of the Shock

Our analysis examines the suspension of 30-year U.S. Treasury bond auctions from Q4 2001 to Q4 2005 as a shock to long-term bond supply. We also study its reintroduction following the U.S. Treasury's May 4, 2005, announcement that it was considering resuming 30-year bond issuance.[13]

The suspension occurred amid U.S. federal budget surpluses in the late 1990s. Beginning in 1998, the federal government ran its first surplus since 1969, peaking at $236 billion in 2000, driven by economic growth, rising tax revenues, and fiscal discipline. With lower borrowing needs, the Treasury reduced bond issuance (Greenwood and Vayanos, 2010).

On Oct. 31, 2001, Peter R. Fisher, Under Secretary of the Treasury for Domestic Finance, referred to these surpluses to justify suspending 30-year bond auctions. Fisher stated, "We do not need the 30-year bond to meet the government's current financing needs, nor those that we expect to face in coming years." He explained that if "sustained surpluses do not materialize as promptly as we now expect" reinstating the bond "would likely be costless to the Treasury." He also emphasized, "The Treasury does not try to outsmart the market..." suggesting the decision was not based on yield curve expectations.

[13] See https://home.treasury.gov/news/press-releases/po749 and https://home.treasury.gov/news/press-releases/js2420 for the suspension and possible resumption announcements.

The Treasury's decision to reintroduce 30-year bond auctions reflected worsening budget conditions. By 2003, forecasts had diverged from initial projections. Bloomberg News reported on July 10, 2003, that "The U.S. 30-year Treasury bond fell in New York trading on mounting speculation that the government will renew sales of that security to finance widening budget deficits." The Congressional Budget Office projected a record $400 billion deficit for 2003, a stark contrast to earlier forecasts (Congressional Budget Office, 2004).

On May 4, 2005, the U.S. Treasury announced plans to consider reintroducing 30-year UST auctions on a semi-annual basis starting Feb. 2006, with a final decision expected in August. That day, *The Wall Street Journal* reported, "analysts said today's announcement makes the move all but certain" (Annett and Patterson, 2005), noting that "The nation's financial picture has changed drastically in recent years. Instead of surpluses, the government is staring down massive long-term borrowing needs."

4 Identification Strategy

We map the bond maturing at $t = 3$ in our model to the 30-year UST bond, excluding UST notes (2–10 years) from the long-term bond category. This approach exploits variations in UST and CMO maturities to examine the effects of suspending 30-year UST bond auctions on quantities and prices (Hypotheses 1 to 3). The diversity of CMO types regarding prepayment exposure enables multiple controls and falsification tests. We also exploit differences in investor elasticity for 30-year USTs. Life insurers, with longer-term liabilities than P&C insurers, exhibit more inelastic demand for long-term bonds and thus have a habitat preference for long-term bonds, whereas P&C insurers behave as non-preferred habitat investors.

Our identification strategy demonstrates that a supply shock to 30-year USTs produces outcomes consistent with the PBM rather than alternative mechanisms. Specifically, the suspension of 30-year UST issuance raises long-term bond prices relative to medium-term bonds, increases long-term PAC issuance relative to long-term SEQs, and boosts life insurers' demand for long-term PACs over medium-term PACs, while leaving their demand for long-term SEQs relative to medium-term SEQs unchanged and while having no effect on P&C insurers' demand for PACs or SEQs.[14]

[14] Gabaix, Krishnamurthy, and Vigneron (2007) also examine CMO heterogeneity by analyzing prepayment

Our identification strategy rests on two premises: First, the suspension and resumption of 30-year UST bond auctions were at least partially unexpected.[15] If fully anticipated, no price reactions would occur at the time of the announcements, so observed price responses support the assumption of surprise.

Second, no unobserved shock produced the same diverse outcomes predicted by the PBM, aligning with the suspension and reversing when auctions resumed. Although our rich set of outcomes and two shocks rule out all alternative explanations we have considered, an unobservable factor could, in theory, mimic these patterns. To rule out this possibility, we build on the empirical procedure of GHS and estimate the relation between long-term PAC purchases and the weighted-average maturity of UST issuances over a 30-year period. The Preferred Habitat Investors' Substitution hypothesis predicts that when UST maturity decreases, preferred-habitat investors increase long-term PAC purchases. A persistent negative relation between UST maturity and PAC purchases by life insurers—excluding the suspension period—further rules out unobservable confounders.

Our identification strategy addresses two key alternative hypotheses that often challenge PBM identification. The signaling hypothesis suggests the suspension signaled expectations of mortgage prepayment, increasing life insurers' demand for PACs (prepayment-insensitive) while reducing demand for SEQs (which lack prepayment protection). However, this hypothesis does not explain why long-term PAC purchases increased more than medium-term PACs, unless the prepayment signal pertained to a period over a decade in the future. Unlike the PBM, if prepayment risk were relevant that far ahead, the signaling hypothesis would also predict a decline in long-term SEQ purchases relative to medium-term SEQs by life insurers. Additionally, P&C insurers would exhibit similar adjustments in PAC and SEQ

risk pricing in Interest-Only (IO) and Principal-Only (PO) tranches. While common, IOs and POs are less prevalent than PACs and SEQs, and life insurers rarely purchase them. Unlike IOs and POs, PAC cash flows remain stable during refinancing waves due to the SUP tranche absorbing prepayment risk.

[15]Some evidence suggests a decline in net issuance was anticipated. In Feb. 2000, Gary Gensler, Under Secretary of the Treasury for Domestic Finance, hinted that the 10-year UST might replace the 30-year UST as the long-term benchmark. However, news sources such as *The Wall Street Journal* (https://www.wsj.com/articles/SB10045483808817113360), CNN (https://money.cnn.com/2001/10/31/markets/longbond/), and *The Economist* (https://www.economist.com/finance-and-economics/2001/11/01/cut-short) described the suspension as a "surprise move." Similarly, while the resumption may have been partly anticipated due to large federal deficits, price reactions to both events suggest the shocks were at least partially unexpected.

purchases. Thus, our empirical setting provides distinct testable predictions that differentiate the signaling hypothesis from the PBM.

Another alternative explanation involves information frictions.[16] If the suspension increased information frictions, we would expect changes in life insurers' demand for SEQs and medium-term PACs. However, such frictions would not affect long-term UST prices, further distinguishing this explanation from the PBM.

5 Data

Our analysis of the 30-year UST bond auction suspension and resumption spans 1997 Q1 to 2007 Q4, beginning in 1997 Q1 when CMO pricing data become available and ending in 2007 Q4 to avoid contamination from the 2008 financial crisis.

To test the Preferred Habitat Investors' Substitution Hypothesis (Hypothesis 1), we merge CRSP Treasury data with CMO issuance data and insurers' bond portfolio data. The CRSP dataset covers all non-callable UST bonds and notes traded during the sample period, with detailed information including CUSIP, daily return, amount outstanding, issuance date, and maturity date.

Figure 2 shows the long-term UST supply shock. USTs are classified as medium-term notes (2 to 10 years) or long-term bonds (over 10 years). Panel A shows total note and bond issuance from 1997 to 2007. Note issuance increased from \$0.4 trillion in 2002 to \$0.6 trillion in 2005, while bond issuance fell from \$16 billion in 2001 to zero from 2002 to 2005, before rebounding to \$26 billion in 2006. Panel B shows UST bond issuance as a share of total notes and bonds, which fell from 6% in 2001 to zero from 2002 to 2005, rising to 4% in 2006.

[Insert Figure 2 Here]

Our CMO dataset covers all standard agency CMOs issued by Freddie Mac, Fannie Mae, and Ginnie Mae from 1997 Q1 to 2007 Q4, sourced from Bloomberg and the Ginnie Mae

[16] Originators often have better information than investors and can assess borrowers' prepayment likelihood using points-contract rate trade-offs (Stanton and Wallace, 1998). Mortgage pass-through pools typically originate from a single lender, meaning private information persists (Downing, Jaffee, and Wallace, 2009). To mitigate this "lemons problem," dealers tranche mortgage pass-throughs, retaining tranches most exposed to prepayment risk (DeMarzo, 2005).

disclosure website. The raw data include 3,325 deals with 148,386 tranches. A deal can have multiple groups of collateral that are separately tranched to create different types of CMOs. We retain only PAC, SUP, and SEQ tranches, resulting in 3,182 deals with 88,431 tranches. For each tranche, we observe CUSIP, issue size, and weighted average life (WAL) at issuance, along with details on the underlying collateral. Table 1 presents summary statistics.

[Insert Table 1 Here]

Table 1, Panel A reports statistics for all agency CMO deals, with an average deal size of $2.3 billion and 45 tranches per deal. Panel B covers PAC and SUP tranches, with 60,715 tranches that account for 41% of all tranches and 38% of total issuance amount. Panel C focuses on SEQs, the second-largest tranche type, with 27,716 tranches that represent 27% of total issuance amount. PAC and SUP tranches have a mean WAL at issuance of 7.7 years, similar to SEQs at 7.8 years.

Life and P&C insurer bond portfolio data come from the NAIC Schedule D - Part 1 database, covering 1997 to 2007. These data include firm-level AUM and bond holdings at the CUSIP level. For each insurer type, we retain insurers that were active during the period and focus on the top 250 insurers by bond AUM in 1999.[17]

To evaluate Hypothesis 1, we construct a quarterly panel of insurers' purchases of newly issued USTs and CMOs by merging CRSP, CMO, and NAIC data. The panel tracks purchases and bond characteristics at the CUSIP level. Focusing on newly issued securities is also appropriate since CMO WAL is measured at issuance. Each quarter, we aggregate purchases for each insurer, calculating total purchases of newly issued medium- and long-term USTs, PACs, and SEQs. CMOs with WALs between 2 and 10 years are medium-term; those over 10 years are long-term, mirroring the UST classification.

Table 2 presents summary statistics on purchases by life and P&C insurers. In 12.5% (1,251/9,984) of life-insurer-quarters, insurers purchase new long-term PACs. Conditional on purchase, the mean amount is $45.5 million, or 0.7% of total fixed income assets. New UST bond purchases occur in 3.6% (355/9,984) of quarters, with a mean purchase of $44.8 million (0.5% of assets). The number of new UST bond purchases is low because there are no

[17] These top 250 life insurers managed 95% ($1.4 trillion) of total fixed income assets, while the top 250 P&C insurers managed 79% ($0.4 trillion) of total fixed income assets.

new issuances from 2002 to 2005 due to the suspension. In contrast, for 1997 to 2001, about 5.9% of firm-quarters involve the purchase of new UST bonds. Long-term SEQs are also common, purchased in 11.5% (1,146/9,984) of life-insurer-quarters, with a mean purchase of $33.4 million (0.5% of assets). Table 2 also shows that P&C insurers purchase more medium-term CMOs than long-term CMOs. They purchase long-term PACs in 5.0% (533/10,644) and medium-term PACs in 6.7% (714/10,644) of firm-quarters, consistent with their more elastic demand for long-term bonds.

[Insert Table 2 Here]

To test the Gap Filling Hypothesis (Hypothesis 2), we analyze CMO issuance data and examine whether long-term agency and corporate bond issuance increased during the suspension. Corporate and agency bond issuance data come from Datastream and Mergent-FISD. For agencies, we focus on non-redeemable benchmark bonds issued by Fannie Mae and Freddie Mac. For corporates, we focus on USD-denominated, fixed-rate investment-grade bonds issued between 1997 and 2007, excluding redeemable, putable, convertible, or exchangeable bonds. We exclude redeemable bonds to ensure comparability with long-term USTs. Like Badoer and James (2016), we focus on bonds issued by non-financial U.S. firms. We obtain credit ratings near issuance from S&P, Moody's, Fitch, and Duff & Phelps.

Figure 5, Panel A shows only one long-term agency benchmark bond issued during the suspension. Panel B shows investment-grade corporate bond issuance.

[Insert Figure 5 Here]

As discussed in Section 4, we address potential confounding shocks unrelated to 30-year UST supply by extending our primary CMO and life insurer dataset (1997-2007) to cover 1995 to 2023. This lets us assess life insurer purchases during placebo periods and the broader CMO-Treasury issuance relation across cycles.

To test the Price Reaction Hypothesis (Hypothesis 3), we use CRSP Treasury data and monthly PAC index returns from the ICE Bank of America Merrill Lynch CMO Index database. These indices, available on the last trading day of each month, provide market

value, total return, effective yield, and duration for PAC portfolios grouped by effective duration.[18] Effective yields and durations are model-based, calculated by the index provider. For Hypothesis 3, we group PACs into medium- and long-duration based on effective duration.

6 Empirical Results

6.1 Preferred Habitat Investors' Substitution Hypothesis

We now turn to Hypothesis 1, which predicts that a negative shock to the excess supply of long-term USTs induces preferred-habitat investors, such as life insurers, to increase their purchases of substitute long-term bonds. We begin by analyzing life insurers' purchases of newly issued PACs and SEQs. We then examine purchases by P&C insurers, whose shorter liabilities make them less likely to exhibit a habitat preference for long-term bonds (Chen, Sun, Yao, and Yu, 2022). Finally, to extend the analysis beyond the suspension and resumption event study, we investigate life insurers' PAC purchases over a 30-year sample period to assess whether their demand for long-term PACs rises when the weighted average maturity of Treasury debt issuances declines.

We define the period from 2001 Q4 to 2005 Q4, when UST bond auctions were suspended, as the *No Auction* period. The subsequent period, from 2006 Q1 to 2007 Q4, when 30-year UST auctions resumed, is referred to as the *Post Period*.

We estimate a difference-in-difference specification. The first difference is the change in the principal amount of newly issued medium- and long-term PACs purchased by insurers during the *No Auction* period relative to the period with UST bond auctions. The second difference captures how this change differs between long-term and medium-term PACs. To do so, we estimate the following specification:

$$\begin{aligned} \Delta PAC_{i,j,q} = {} & \beta_1 \times \mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_q \\ & + \beta_2 \times \mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q \\ & + \beta_3 \times \mathbb{1}(\text{LT})_{i,j} + \mu_j + \eta_q + \text{Controls}_{i,j,q} + \epsilon_{i,j,q}. \end{aligned} \tag{7}$$

The dependent variable is the amount of newly issued medium- or long-term PACs purchased

[18] We also collect data on SUPs (CMSZ) analyzed in the appendix. See Galdi, Goldblatt, and Zhang (2006) for details.

by insurance company j in quarter q.[19] We separately aggregate purchases of medium- and long-term PACs, resulting in two observations (i) per quarter q for each insurance company j. Purchases are measured in millions of dollars. Medium-term PACs are defined as those with a WAL between 2 and 10 years at issuance (similar to UST notes), while long-term PACs have a WAL greater than 10 years at issuance (similar to UST bonds). The variable $\mathbb{1}(\text{LT})_{i,j}$ is an indicator equal to one for insurer j's purchases of long-term PACs ($i = 1$) and zero for medium-term PACs ($i = 0$). The coefficient β_1 captures whether purchases of long-term PACs change relative to medium-term PACs during the *No Auction* period. The coefficient β_2 measures whether purchases of long-term PACs return to pre-suspension levels after auctions resume. The term μ_j denotes insurer fixed effects, which account for time-invariant differences across insurers, such as varying propensities to invest in PACs. The term η_q denotes quarter fixed effects, which control for aggregate trends, including changes in interest rates. To control for time-varying insurer-specific factors that could affect demand for both medium- and long-term CMOs, we include controls, $\text{Controls}_{i,j,q}$, which consist of insurer j's purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) SEQs in quarter q ($SEQ_{i,j,q}$). Standard errors are double-clustered by insurer and quarter.

The key identifying assumption underlying our difference-in-differences specification is that, in the absence of the suspension of 30-year UST bond auctions, insurance companies' investments in long-term and medium-term PACs would have followed parallel trends, after controlling for investments in SEQs and the fixed effects. Figure 3 presents the dynamics of Equation 7 for life insurers. The figure shows that, prior to the suspension of 30-year UST auctions, purchases of medium-term and long-term PACs had similar activity, supporting the parallel trends assumption.

[Insert Figure 3 Here]

Following the suspension announcement, life insurers' purchases of newly issued long-term PACs increased sharply after 2001 Q4, with average quarterly purchases peaking at $18.0

[19] We focus on purchases because the PBM predicts increased creation of substitutes to meet preferred-habitat demand, but does not imply specific effects on sales. Moreover, life insurers are primarily buy-and-hold investors (Chodorow-Reich, Ghent, and Haddad, 2021), and reductions in holdings may reflect amortization rather than active sales.

million per insurer in 2002 Q3.[20] Purchases remained elevated through 2004, though at somewhat lower levels, before returning to normal in 2005. The reversion in long-term PAC purchases before the resumption of 30-year UST auctions aligns with the heightened market expectations in 2003 regarding such a resumption, as discussed in Section 3. Moreover, life insurers purchased approximately 25% of the total UST bonds issued at the 2006 resumption, compared to around 10% in the pre-period and about 5% in 2007. Additionally, demand for the 30-year UST bond was unexpectedly strong at the auction's resumption.[21] This surge in demand in 2006 is in line with preferred-habitat investors delaying long-term bond purchases during 2004–2005 in anticipation of the resumption of UST bond auctions. After auctions resumed in Feb. 2006, there is no evidence of any sustained differences in long-term versus medium-term PAC purchase behavior relative to the period before the suspension.

Our estimation results for Equation 7 support the prediction that habitat-preference investors, such as life insurers, substitute UST bonds with long-term PACs when the net supply of long-term USTs decreases. In Table 3, Panel A, Column (1), the coefficient β_1 indicates that the average insurer increased its purchases of newly issued long-term PACs by approximately \$6.8 million per quarter during the *No Auction* period. Column (4), which scales purchases by lagged AUM, shows that this increase represents about 0.06 percentage points of an insurer's total fixed income portfolio. The \$6.8 million (0.06 percentage point) increase corresponds to 18.8% (17.2%) of the standard deviation of quarterly PAC purchases, which is \$36.2 million (0.35 percentage points). When 30-year UST auctions resumed in the *Post Period*, the coefficient β_2 shows no significant change in PAC purchases relative to the pre-suspension period. This pattern highlights that any unobserved shock explaining the results would need to reverse after auctions resumed. Additional robustness checks are presented in the Internet Appendix.[22]

[20]The increase in standard error bars during the *No Auction* period is consistent with heterogeneous treatment responses across firms. This heterogeneity is further illustrated in Table A6, which compares responses between large and small life insurers.

[21]See New York Times, February 9, 2006 for details.

[22]Table A2 applies a logarithmic transformation to mitigate potential skewness. Table A3 restricts the medium-term CMO sample to PACs with WALs between 5 and 10 years, improving comparability between medium- and long-term CMOs. Table A4 incorporates secondary market purchases. Table A5 shows that the effect is strongest for the safest PAC CMOs, which offer the widest prepayment protection bands. Table A6 demonstrates that the effect is not driven solely by a few large insurers. Finally, Table A7 examines PAC purchases during two placebo periods with similar interest rate declines to 2001, but without targeted

[Insert Table 3 Here]

To assess the economic significance of these results, we examine the extent to which the increase in PAC purchases during the *No Auction* period serves as a substitute for UST bonds. Specifically, we estimate the volume of newly issued UST bonds that life insurers would have purchased had auctions continued, using a difference-in-differences specification similar to Equation 7. The first difference captures the change in the principal amount of newly issued UST notes and bonds purchased by life insurers during the *No Auction* period relative to other years. The second difference captures how this change differs between purchases of UST bonds (long-term) and UST notes (medium-term).

Column (2) shows that life insurers reduce their purchases of UST bonds by $12.5 million during the *No Auction* period. The coefficient β_2 indicates no significant difference in UST bond purchases in the *Post Period* relative to the pre-suspension period. The $6.8 million increase in long-term PAC purchases reported in Column (1) is similar in magnitude to the $12.5 million decrease in UST bond purchases in Column (2). When scaling by insurers' AUM, the 0.06 percentage point increase in long-term PAC purchases in Column (4) closely matches the 0.07 percentage point decline in UST bond purchases shown in Column (5). Together, these results suggest an economically meaningful substitution between UST bonds and long-term agency PACs, consistent with Portfolio Balance Mechanism (PBM) predictions.

A key part of our PBM identification assumption is that the suspension of 30-year UST issuance increases demand for long-term PACs relative to medium-term PACs, without affecting demand for long-term SEQs relative to medium-term SEQs. While life insurers could, in principle, substitute UST bonds with long-duration SEQs, doing so would expose them to significant prepayment risk, which can materially shorten the SEQs' effective lives. As a result, long-term PACs are close substitutes for long-term UST bonds, whereas SEQs are not. The PBM predicts that habitat-preference investors respond to a reduction in UST supply by reallocating toward close substitutes, such as PACs, without altering their demand for SEQs. In contrast, the signaling and information friction hypotheses predict broader shifts in life insurers' asset purchases, especially in information-sensitive SEQs.

shocks to 30-year UST supply, and finds no corresponding increase in purchases during those periods.

We exploit the heterogeneity in prepayment risk between PACs and SEQs to conduct falsification tests. Specifically, we estimate a difference-in-differences specification similar to Equation 7, where the first difference captures the change in the principal amount of medium- and long-term SEQs held by insurers during the *No Auction* period relative to periods with regular UST bond auctions. The second difference captures how this change differs between long-term and medium-term SEQs.

Consistent with the PBM, the coefficient β_1 in Columns (3) and (6) of Table 3 shows that life insurers did not increase their purchases of newly issued long-term SEQs during the *No Auction* period. Similarly, the coefficient β_2 indicates no significant change in SEQ purchases in the *Post Period* relative to the pre-suspension period. Together, these results show that life insurers' purchases of long-term SEQs remained stable throughout the sample period, despite Table 2 showing that life insurers regularly purchase newly issued SEQs.[23]

Next, we examine P&C insurers' purchases of newly issued PACs and SEQs in Table 3, Panel B. Hypothesis 1 predicts that non-preferred-habitat investors are less likely than preferred-habitat investors to substitute long-term USTs with other long-term bonds. Consistent with this prediction, Columns (1) and (4) show no increase in long-term PAC purchases by P&C insurers during the *No Auction* period; if anything, the coefficients are negative. Columns (2) and (5) document a significant reduction in long-term UST purchases, consistent with the suspension of 30-year UST issuance. And, Column (3) shows no change in P&C insurers' SEQ purchases, while Column (6) suggests a decline.

Lastly, we extend our analysis of Hypothesis 1 using an almost three-decade sample (1995 to 2023) to examine the broader relation between the WAM of U.S. Treasury issuances and life insurers' demand for long-term PACs. Specifically, we estimate the following specification:

$$\begin{aligned}\Delta PAC_{i,j,q} = \beta_1 \times \mathbb{1}(\text{LT})_{i,j} \times \text{WAM UST}_q \\ + \beta_2 \times \mathbb{1}(\text{LT})_{i,j} + \mu_j + \eta_q + \text{Controls}_{i,j,q} + \epsilon_{i,j,q}.\end{aligned} \tag{8}$$

This specification largely follows Specification 7, with one key difference: the inclusion of the explanatory variable *WAM UST*$_q$, which represents the weighted average maturity of

[23]For example, the Protective Life Corporation 2004 10-K reports that 41.6% of its mortgage-backed securities portfolio was invested in PAC tranches, while 38.1% was in SEQ tranches. Similarly, the Americo Life, Inc. 2001 10-K reports that 33% of its CMO portfolio consisted of SEQ tranches.

Treasury issuances in quarter q, weighted by issuance amounts. For reopened issuances, maturities are calculated from the reopening date. The WAM for quarter q is given by WAM $\text{UST}_q = \sum_i(\text{Issuance Amount}_{i,q} \times \text{Time to Maturity}_{i,q}) / \sum_i \text{Issuance Amount}_{i,q}$, where $\text{Issuance Amount}_{i,q}$ is the amount issued for security i in quarter q, and the number of years until maturity at issuance is $\text{Time to Maturity}_{i,q}$.

Table 4 Panel A presents the results. Columns (1) and (4) show a significant negative relation between life insurers' demand for long-term PACs and $WAM\ UST_q$, indicating that when the U.S. Treasury issues fewer long-term USTs, life insurers increase their purchases of long-term PACs. Columns (2) and (5) show this relation remains robust even when excluding the suspension period and the financial crisis period (pre-2002, 2007, and post-2010).

[Insert Table 4 Here]

For an omitted variable to bias the estimates in Table 4, it would need to simultaneously affect both $WAM\ UST_q$ and life insurers' demand for long-term PACs relative to medium-term PACs, after controlling for SEQ demand. However, as noted by Greenwood, Hanson, and Stein (2010), the maturity of government debt is endogenous and may be influenced by some of the same factors driving long-term PAC (but not SEQ) demand. To address this concern, we instrument for government debt maturity using the ratio of government debt to GDP. These two variables are strongly positively correlated: when government financing needs rise, the Treasury tends to issue longer-maturity debt. The first-stage F-statistic exceeds 10,000, indicating a strong instrument. Moreover, the debt-to-GDP ratio, which largely reflects past fiscal policy, is plausibly exogenous to omitted factors driving long-term PAC creation, supporting its validity as an instrument. Reassuringly, Columns (3) and (6) report results consistent with the baseline estimates.[24]

Additionally, Table 4 Panel B shows no relationship between $WAM\ UST_q$ and P&C insurers' demand for long-term PACs. Therefore, any omitted variable would need to account for the observed shift in life insurers' demand for long-term PACs while leaving P&C insurers' demand unchanged.

[24]Table A8 replaces $WAM\ UST_q$ with the proportion of UST issuances with WALs over 10 years.

6.2 Gap Filling Hypothesis

We now examine Hypothesis 2. Specifically, we examine whether mortgage dealers responded by increasing the creation of long-term PACs relative to long-term SEQs during the *No Auction* period. To test this, we estimate the following panel regression:

$$\begin{aligned}\text{Issuance Amount}_{i,q} = \beta_1 \times \mathbb{1}(\text{No Auction})_q \times \mathbb{1}(\text{Long-term PAC})_i \\ + \beta_2 \times \mathbb{1}(\text{Post Period})_q \times \mathbb{1}(\text{Long-term PAC})_i \\ + \beta_3 \times \mathbb{1}(\text{Long-term PAC})_i + \eta_q + \epsilon_{i,q}.\end{aligned} \tag{9}$$

The outcome variable is the total amount of long-term PAC or long-term SEQ tranches (security i) issued in quarter q. Since we separately aggregate issuance amounts for long-term PACs and long-term SEQs, the dataset contains two observations per quarter. The indicator variable $\mathbb{1}(\text{Long-term PAC})_i$ equals one for the time series of long-term PAC issuance and zero for the time series of long-term SEQ issuance.

[Insert Table 5 Here]

In Column (1) of Table 5, the coefficient β_1 indicates that the average issuance of long-term PACs increased by approximately $5.8 billion per quarter during the suspension period, relative to the issuance of long-term SEQs. When UST bond auctions resumed in the *Post Period*, the coefficient β_2 shows no significant difference in long-term PAC creation relative to long-term SEQ creation compared to the pre-suspension period.

Figure 4 plots the quarterly difference between long-term PAC and SEQ issuance amounts. Prior to the suspension of 30-year UST auctions, the volume of long-term PAC issuance is similar to long-term SEQ issuance. However, following the suspension announcement, long-term PAC issuance rose sharply, exceeding long-term SEQ issuance by approximately $15 billion in 2003 Q1 and 2003 Q2. Consistent with the moderation in life insurers' demand for PACs in 2004 and 2005, shown in Figure 3, Figure 4 shows a similar decline in long-term PAC issuance during this period. This pattern is consistent with rising expectations that the U.S. Treasury would resume 30-year UST auctions. After the auctions resumed, long-term PAC and SEQ issuance volumes remained broadly similar.

[Insert Figure 4 Here]

The PBM predicts that a decrease in the supply of UST bonds leads to an increase in the issuance of substitute securities to meet the demand of preferred-habitat investors. Therefore, it is useful to compare the economic magnitudes of the results in Tables 3 and 5. Our results show that, during the *No Auction* period, life insurers — a key segment of preferred-habitat investors — increased their PAC purchases by approximately \$6.8 billion per year ($4 \times 250 \times$ \$6.8 million, from Table 3), substituting for an estimated \$12.5 billion per year of UST bonds they would have purchased absent the suspension ($4 \times 250 \times$ \$12.5 million, also from Table 3). At the same time, the issuance of long-term PACs relative to long-term SEQs increased by \$23.2 billion per year ($4 \times$ \$5.8 billion, from Table 5). These amounts are broadly similar in magnitude and align with the \$16 billion annual reduction in UST bond issuance shown in Figure 2.[25]

The model further predicts that issuers with lower arbitrage costs fill the gap to a greater extent. The extent to which GSEs and corporations issue bonds to fill this gap depends on the relative constraints they face compared to mortgage dealers.[26] Whether preferred-habitat investors ultimately substitute long-term USTs with PACs, agency debt, or corporate bonds remains an open empirical question which we address with the following specification:

$$\begin{aligned} \text{Issuance Amount}_{i,q} = {} & \beta_1 \times \mathbb{1}(\text{No Auction})_q \times \mathbb{1}(\text{Long-term})_i \\ & + \beta_2 \times \mathbb{1}(\text{Post Period})_q \times \mathbb{1}(\text{Long-term})_i \\ & + \beta_3 \times \mathbb{1}(\text{Long-term})_i + \eta_q + \epsilon_{i,q}. \end{aligned} \tag{10}$$

The outcome variable is the amount of long-term or medium-term corporate or agency bonds (security i) issued in quarter q. Since we separately aggregate issuance amounts for long-term and medium-term securities, there are two observations per quarter for each issuer. Long-term bonds are defined as those with a WAL exceeding 10 years. We focus on the issuance of straight corporate and agency bonds, as described in Section 5.

[25] Since the creation of long-term PAC tranches inherently requires the formation of medium-term PAC tranches, we also expect an increase in the share of pass-through collateral allocated to PAC tranches relative to SEQ tranches. Figure A1 shows an increase in collateral used to create PAC tranches compared to SEQ tranches, and Table A9 confirms the statistical significance.

[26] Table A1, Panel A, shows that life insurers frequently invest in corporate and agency bonds. Other bond types in their portfolios are not natural substitutes for the 30-year UST bond. Mortgage pass-throughs expose investors to significant prepayment risk, private-label (residential) CMOs primarily tranche credit risk rather than prepayment risk, and most commercial mortgage-backed securities have WALs of less than 10 years.

The results in Table 6 provide no evidence of an increase in long-term agency bond issuance, as shown in Columns (1) and (2). These findings suggest that the GSEs did not respond to the shock to the supply of 30-year USTs by issuing agency debt potentially due to the high costs associated with deviating from their target debt maturities. The GSEs are highly regulated and required to manage the duration gap between their mortgage portfolio and their liabilities. In contrast, generating fees by creating additional long-term PACs from pass-through collateral does not affect the agencies' capital structure, making this form of gap-filling possibly more feasible for them.

The results in Table 6 also show no robust increase in investment-grade corporate bond issuance, as shown in Columns (3) and (4). Specifically, Column (3) shows some significant evidence of an increase in long-term corporate bond issuance versus medium-term corporate bond issuance. However, this difference is negative -0.11 and non-significant when examining the natural logarithm of these quantities. This indicates that if anything, long-term corporate issuance declined 11% more than medium-term bond issuance declined during the suspension period. Additionally, both columns show a significant increase in long-term corporate bond issuance after UST bond issuances resume, making it difficult to attribute any rise in corporate bond issuance specifically to the suspension of UST issuances. Overall, the evidence suggests that corporations are more constrained than PAC issuers in filling the gap left by the suspension of the 30-year bond auction.

[Insert Table 6 Here]

Figure 5 presents the quarterly time series of agency and corporate issuances. Panel A highlights that only one long-term agency debt issuance occurred during the *No Auction* period, in 2002 Q1.[27] Panel B shows that long-term corporate bond issuances generally declined from $2.8 billion per quarter prior to the *No Auction* period to $0.8 billion per quarter during the suspension period.[28] Perhaps, more striking is the decrease in the issuance

[27]Consistent with the idea that benchmark long-term agency debt serves as a substitute for 30-year UST bonds, Louise Herrle, Freddie Mac's Vice President and Treasurer, stated after the 2002 Q1 issuance: "Investors showed strong demand for the unrivaled liquidity of this $6 billion issue—the largest non-sovereign bond in the 30-year sector. Interest in the issue was broad-based, with above-average international participation." Following this issuance, Freddie Mac did not issue any additional benchmark 30-year bonds and instead shifted to issuing long-term PACs.

[28]Mergent-FISD covers 95% of the bonds in the SDC sample used by Badoer and James (2016). However,

of medium-term corporate bonds during and after the suspension period. This decrease in medium-term corporate bonds explains the results in Table 6 Column (3) showing a positive differential change in long-term corporate bond issuance versus medium-term corporate bond issuance. Moreover, the difference in the scale of medium- and long-term corporate bond issuance is large, which explains why, when taking logs, the increase in levels disappears.[29]

[Insert Figure 5 Here]

Lastly, motivated by the strong demand for long-term PACs by life insurers when the WAM of UST issuances declines over the 1995–2023 period in Table 4, we examine whether mortgage dealers respond by increasing long-term PAC issuance under similar conditions. Table 7 shows a significant negative relation between $WAM\ UST_q$ and the ratio of long-term PACs to total long-term PACs and SEQs issued in quarter q. Column (1) presents the result without controls, while Column (2) adds controls for the federal funds rate, the spread between 6-month and 1-month Fed funds futures, the term spread between 30-year and 1-year USTs, the investment-grade credit spread, a mortgage refinancing index, and a linear trend. Column (3) confirms the result holds after excluding both the suspension period and the financial crisis. Column (4) instruments $WAM\ UST_q$ using the ratio of total debt outstanding to GDP in quarter q (first-stage F-statistic: 76.4). Column (5) reports an elasticity of -0.53, indicating that a 1% decrease in $WAM\ UST_q$ is associated with a 0.53% increase in the proportion of long-term PACs created by mortgage dealers.[30]

[Insert Table 7 Here]

6.3 Price Reaction Hypothesis

Hypothesis 3 predicts that a negative shock to the excess supply of long-term UST bonds increases both their prices and the prices of long-term PACs. To test this hypothesis, we

as noted by Chen, Mao, and Wang (2010), the SDC data lacks a flag for callable bonds with prepayment risk, which is crucial for identifying corporate bonds that could serve as substitutes for USTs. Moreover, Mergent-FISD indicates that 75.5% of bonds with a WAL exceeding 10 years are redeemable. By contrast, for medium-term notes, only 38.5% are redeemable. Consequently, the figure correctly suggests that few long-term, non-redeemable investment-grade corporate bonds are issued.

[29]Table A10 shows no increase in life insurers' purchases of these corporate and agency bonds during the suspension period.

[30]Table A11 confirms robustness using the share of UST issuances with WALs greater than 10 years. Table A12 shows holds using collateral tranched into PACs and SEQs.

examine the daily returns of USTs and the calendar-month returns of PACs on Oct. 31, 2001, the date the U.S. Treasury announced the indefinite suspension of 30-year UST bond auctions. We also analyze their returns on May 4, 2005, when the U.S. Treasury announced the possible reversal of the suspension.

Figure 6 shows that on Oct. 31, 2001 — the day the U.S. Treasury announced the suspension of 30-year bond auctions — the daily return difference between the on-the-run 30-year bond and the on-the-run 10-year note spiked to approximately 3.7%, the largest positive daily return difference in the 1997–2007 sample period. This sharp reaction suggests the market was surprised by the suspension announcement. To the extent the suspension was partially anticipated, this estimate understates the full price reaction. On May 4, 2005, when the possible reversal of the suspension was announced, the 30-year bond less 10-year note return fell by approximately 1.4%, consistent with the model's limits-to-arbitrage mechanism.[31]

[Insert Figure 6 Here]

Table 8 Panel A shows that these UST returns are highly statistically significant, consistent with the market reacting sharply to both the suspension and its subsequent reversal. To assess the statistical significance of these market reactions, we calculate the distribution of daily returns from January 1, 1997, to August 30, 2001, a period preceding the announcement. We then compare the observed announcement-day returns to this historical distribution. The t-statistic for the returns at the suspension announcement is 13.7 and is -5.0 at the reversal announcement.

[Insert Table 8 Here]

Table 8 Panel B also presents the daily yield changes on the suspension and reversal announcement days for the on-the-run 30-year UST bond and its difference with the on-the-run 10-year UST note. We find that the UST bond yield dropped by 33 bp following the

[31] See Appendix Figure A2 for additional annotations. Consistent with our model (Equation 6), in which a long-term shock to UST bond supply leads to a persistent premium, Figure A3 shows that the large increase in cumulative returns on October 31, 2001 persists throughout the suspension period before reversing after the resumption announcement.

suspension announcement, with a relative decline of 19 bp compared to the 10-year UST note.[32] Yields increased significantly by 12 bp at the reversal announcement.

Next, we examine the prices of long-duration PACs around the suspension announcement. Table 8, Panel C, reports the monthly return difference between agency PAC bonds with long effective durations (nine or more years) and medium durations (seven to eight years). Medium-duration PACs have durations similar to 10-year UST notes.[33] In Oct. 2001, the return difference was 3.9% with a t-statistic of 4.3. Figure 7 plots this difference over the full sample, showing that the Oct. 2001 price movement was highly unusual. We find no return effect around the resumption announcement in May 2005. This may reflect the use of calendar-month PAC returns, which are highly correlated with UST bond returns. Although UST bond prices fell on the reversal announcement date, they rose 2.65% over the month, explaining the positive monthly PAC returns.[34]

[Insert Figure 7 Here]

Lastly, Table 8, Panel D, examines changes in Fed funds futures prices around the suspension and reversal announcements. These contracts settle based on the average fed funds rate for the contract month. We analyze contracts maturing one, six, and nine months ahead — the longest available maturities during the sample period. The signaling hypothesis suggests these announcements could convey information about future interest rates, which would be reflected in Fed funds futures prices. However, we find no evidence of such effects.

Overall, the observed price movements are consistent with Hypothesis 3. These findings support the view that UST supply shocks affect bond prices because arbitrageurs cannot fully absorb the excess demand from investors with inelastic demand for long-term safe assets. As a result, shocks to long-term UST supply lead to adjustments in the term premium, as shown in Equation 6. PAC price changes further supports our evidence that supply shocks to UST bonds increase demand for alternative safe assets among habitat-preference investors.

[32] Consistent with Bernanke, Reinhart, and Sack (2004), if we examine yield changes from Oct. 30, 2001 to Novi, 2001, we calculate 43 bp.

[33] On Oct. 30, 2001, the yield on the 10-year UST note was 4.5%, implying a duration between seven and eight years.

[34] Table A13 documents a strong relation between long-term PAC and UST bond monthly returns. Also, our PBM identification does not rely on SUP price reactions. As shown in Figure A4, SUP returns exhibit no significant changes. Additional details are provided in the appendix.

It is instructive to compare the effect in Table 8 to prior studies examining the impact of supply shocks on UST prices. To do so, we estimate the size of the 30-year UST supply shock. Assuming perfect foresight — where investors correctly anticipated the suspension would last four years — the shock amounts to a $64 billion reduction in 30-year bond supply ($16 billion per year), leading to a 33 bp drop in its yield. This implies a yield impact of 0.52 bp per billion-dollar reduction, larger than most estimates in the literature. For comparison, Wiliams (2014) surveys estimates from various studies, which generally find that a $600 billion supply shock reduces 10-year UST yield by 15 to 25 bp — equivalent to 0.025 to 0.042 bp per billion dollars.

Among the estimates listed in Wiliams (2014), the multiplier of 0.52 bp per billion-dollar shock is closest to the estimate from Bernanke, Reinhart, and Sack (2004). As reported by Wiliams (2014), Bernanke, Reinhart, and Sack (2004) estimate that a $600 billion supply shock reduces the 10-year yield by 400 bp, implying a multiplier of 0.66 bp per billion dollars.

It is particularly notable that our estimate aligns closely with Bernanke, Reinhart, and Sack (2004), despite examining different shocks, because both studies cover the same period. Bernanke, Reinhart, and Sack (2004) estimate their multiplier for USTs with maturities of 10 years or less using UST purchases by Japanese monetary authorities from January 3, 2000, to March 3, 2004. The relatively large size of these multipliers, compared to others in the literature, along with the wide variation in estimates summarized by Wiliams (2014), suggests that time-varying factors play a significant role in determining multiplier size.

The multiplier in Equation 6 increases with the risk penalties of arbitrageurs (η_h) and mortgage dealers (η_f), and decreases with the average demand elasticity of long-term bond investors ($\overline{\alpha}$). In practice, these parameters vary over time, implying a time-varying multiplier. For example, D'Amico and King (2013) show that large-scale asset purchases have greater effects during high market stress, when arbitrageurs face higher risk penalties.

During the period when both our multiplier and that of Bernanke, Reinhart, and Sack (2004) are estimated, marginal investors in USTs may have been particularly inelastic. The suspension followed years of Treasury bond buybacks and budget surpluses, which likely led investors with more elastic demand to shift into alternative bonds prior to the suspension, reducing $\overline{\alpha}$ and increasing the multiplier. This variation in demand elasticity may help

explain some of the differences in multipliers reported by Wiliams (2014). It also aligns with Kaminska, Kontoghiorghes, and Ray (2024), who argues that the multipliers for quantitative easing (QE) and quantitative tightening (QT) differ due to shifts in the demand elasticities of marginal investors across these episodes.[35]

The price reaction on the day of the auction resumption announcement is also consistent with a relatively high multiplier. The actual issuance of the 30-year U.S. Treasury bond in Feb. 2006 was $14.831 billion. Applying the 0.52 bp per billion-dollar multiplier and assuming perfect foresight implies an expected yield increase of approximately 8 bp for the 30-year bond.[36] This estimated price reaction closely matches the observed 11 basis point increase in the 30-year bond yield on the day the Treasury announced it was considering resuming 30-year bond auctions.

7 Conclusion

The PBM has been used to explain a variety of important capital market phenomena. For instance, the PBM can help explain the impact of QE policies on the real economy as well as the connection between the purchases by the GSG countries of long-term UST bonds and the significant increase in securitization before the financial crisis (Bernanke, 2006, 2010, 2011). Although the PBM provides a possible explanation for the events leading up to the financial crisis and the effectiveness of QE, identifying the PBM poses challenges, as it requires observing changes in habitat-preference investors' portfolios due to UST supply shocks and attributing these changes to a substitution effect.

Our findings provide unusually clean evidence for the PBM. We provide direct evidence that, in response to the shock to the supply of 30-year UST, the prices and issuances of a close substitute (agency-PACs) also increased. Most importantly, habitat investors, namely

[35] As an alternative to the perfect foresight assumption, we can infer the expected suspension duration using literature-based multipliers. Applying the 0.16 bp per billion multiplier from D'Amico and King (2013), reported in Wiliams (2014), the market would have expected the suspension to last approximately 16 years ($43/[0.16 \times 16]$). This is consistent with the Treasury's expectation of prolonged budget surpluses at the time of the suspension announcement.

[36] The perfect foresight assumption is partly supported by a letter dated July 22, 2005, from The Bond Market Association (now SIFMA) and its Primary Dealers Committee to U.S. Treasury Assistant Secretary for Financial Markets Timothy Bitsberger, recommending the reintroduction of a 30-year nominal bond in Feb. 2006 with an initial issuance size between $12 billion and $18 billion. See Comments to the U.S. Department of the Treasury on the Resumption of 30-Year Treasury Bonds.

life insurers, substituted their regular purchases of UST bonds during the suspension period with purchases of agency-PACs. And, these changes revert with the reintroduction of 30-year UST auctions. More generally, in a 30-year sample, we find that when the maturity of UST issuances declines, long-term PAC issuance increases to meet heightened demand from life insurers. By contrast, investors with more elastic demand for long-term USTs (P&C insurers) did not shift into long-term agency PACs.

Our setting capitalizes on the suspension of UST bond auctions (and its reversal), as well as the heterogeneity in USTs, agency CMO tranche types, and insurer types. Any alternative explanation for our findings would have to account for the variation in the price of long- versus medium-term bonds at the suspension announcement, why life insurers intensified their acquisitions of long-term PACs over medium-term PACs without altering their typical purchases of SEQs during the no-auction period, why P&C demand for PACs did not change, and why the issuance of long-term PACs increased relative to long-term SEQs. Thus, the totality of our findings allows for unambiguous identification of the PBM.

Our paper indicates at least two areas for future research. First, the heterogeneity of the agency-CMO market is relatively unexplored. Our clean identification of the PBM exploring the diversity of the agency-CMO market indicates that it is an excellent laboratory to study important questions in Financial Economics. Second, the identification of the PBM suggests that future research investigating the role of the PBM in the pre-crisis increase in securitization and in QE is promising. Although our identification of the PBM supports the idea that the PBM played a role in the pre-crisis increase in securitization and the effect of QE, the importance of the PBM relative to other mechanisms influencing these significant phenomena is still an open question.

References

Acharya, Viral V., Philipp Schnabl, and Gustavo Suarez, 2013, Securitization without risk transfer, *Journal of Financial Economics* 107, 515–536.

ACLI, 2022, Life insurers fact book 2022, *American Council of Life Insurers Discussion Paper*.

Annett, Tim, and Scott Patterson, 2005, Q&A: Return of the long bond: Why it's back on the table, and what it would mean, *The Wall Street Journal*.

Arcidiacono, Nicholas, Larry Cordell, Andrew Davidson, and Alex Levin, 2013, Understanding and measuring risks in agency CMOs, *FRB of Philadelphia Working Paper No. 13-8*.

Badoer, Dominique C., and Christopher M. James, 2016, The determinants of long-term corporate debt issuances, *The Journal of Finance* 71, 457–492.

Barclay, Michael J., and Clifford W. Smith, 1995, The maturity structure of corporate debt, *The Journal of Finance* 50, 609–631.

Begley, Taylor A., and Amiyatosh Purnanandam, 2016, Design of financial securities: Empirical evidence from private-label rmbs deals, *The Review of Financial Studies* 30, 120–161.

Bernanke, Ben S., 2006, Reflections on the yield curve and monetary policy, *Remarks before the Economic Club of New York*.

——— , 2010, The economic outlook and monetary policy, *Remarks at the Federal Reserve Bank of Kansas City Economic Symposium*.

——— , 2011, Global imbalances: Links to economic and financial stability, *Remarks at the Banque de France Financial Stability Review Launch Event*.

——— , Carol Bertaut, Laurie Pounder DeMarco, and Steven Kamin, 2011, International capital flows and the returns to safe assets in the United States, 2003-2007, *International Finance Discussion Papers*.

Bernanke, Ben S., Vincent R. Reinhart, and Brian P. Sack, 2004, Monetary policy alternatives at the zero bound: An empirical assessment, *Brookings Papers on Economic Activity* 2.

Bertaut, Carol, Laurie Pounder DeMarco, Steven Kamin, and Ralph Tryon, 2012, ABS inflows to the United States and the global financial crisis, *Journal of International Economics* 88, 219–234.

Breckenfelder, Johannes, and Veronica De Falco, 2023, Investor heterogeneity and large-scale asset purchases, *Harvard University working paper*.

Chen, Xuanjuan, Zhenzhen Sun, Tong Yao, and Tong Yu, 2022, In search of habitat, *The Review of Asset Pricing Studies* 13, 266–306.

Chen, Zhaohui, Connie X. Mao, and Yong Wang, 2010, Why firms issue callable bonds: Hedging investment uncertainty, *Journal of Corporate Finance* 16, 588–607.

Chodorow-Reich, Gabriel, Andra Ghent, and Valentin Haddad, 2021, Asset insulators, *Review of Financial Studies* 34, 1509–1539.

Congressional Budget Office, 2004, The budget and economic outlook: Fiscal years 2005 to 2014, Report to the senate and house committees on the budget Congress of the United States Prepared under the supervision of Douglas Holtz-Eakin, Director.

Copeland, Adam, Antoine Martin, and Michael Walker, 2011, Repo runs: Evidence from the tri-party repo market, Staff Reports 506 Federal Reserve Bank of New York.

Culbertson, J. M., 1957, The term structure of interest rates, *The Quarterly Journal of Economics* 71, 485–517.

Davidson, Andrew, Anthony Sanders, Lan-Ling Wolff, and Anne Ching, 2008, Structuring collateralized mortgage obligations and interest-only/principal-only securities, in *Handbook of Finance* Chapter 33, John Wiley & Sons, Ltd.

DeMarzo, Peter M., 2005, The pooling and tranching of securities: A model of informed intermediation, *The Review of Financial Studies* 18, 1–35.

Downing, Chris, Dwight Jaffee, and Nancy Wallace, 2009, Is the market for mortgage-backed securities a market for lemons?, *The Review of Financial Studies* 22, 2457–2494.

Duarte, Jefferson, and Douglas A. McManus, 2016, Mortgage-related securities (MRSs), in Pietro Veronesi, ed.: *Handbook of Fixed-Income Securities* pp. 53–73 John Wiley and Sons Inc.

D'Amico, Stefania, and Thomas B. King, 2013, Flow and stock effects of large-scale treasury purchases: Evidence on the importance of local supply, *Journal of Financial Economics* 108, 425–448.

Fabozzi, Frank J., and Chuck Ramsey, 1999, *Collateralized mortgage obligations: Structures and analysis.* (John Wiley & Sons).

Fleming, Michael J., 2000, Financial market implications of the federal debt paydown, *Brookings Papers on Economic Activity* 2000, 221–251.

Gabaix, Xavier, Arvind Krishnamurthy, and Olivier Vigneron, 2007, Limits of arbitrage: Theory and evidence from the mortgage-backed securities market, *The Journal of Finance* 62, 557–595.

Galdi, Phil, Mark Goldblatt, and Guihua Zhang, 2006, Introducing CMO indices, Discussion paper, Merrill Lynch research.

Gennaioli, Nicola, Andrei Shleifer, and Robert W. Vishny, 2012, Negleted risks, financial innovation and financial fragility, *Journal of Financial Economics* 104, 452–468.

——— , 2013, A model of shadow banking, *The Journal of Finance* 68, 1331–1363.

Gorton, Gary, and Andrew Metrick, 2013, Chapter 1 – securitization, in George M. Constantinides, Milton Harris, and Rene M. Stulz, ed.: *Handbook of the Economics of Finance* pp. 1–70 Volume 2, Elsevier.

Greenwood, Robin, Samuel Hanson, and Jeremy C. Stein, 2010, A gap-filling theory of corporate debt maturity choice, *The Journal of Finance* 65, 993—1028.

Greenwood, Robin, and Dimitri Vayanos, 2010, Price pressure in the government bond market, *The American Economic Review* 100, 585–590.

——— , 2014, Bond supply and excess bond returns, *The Review of Financial Studies* 27, 663–713.

Greenwood, Robin, and Annette Vissing-Jorgensen, 2018, The impact of pensions and insurance on global yield curves, *Harvard Business School Working Papers 18-109*.

Harford, Jarrad, Sandy Klasa, and William F. Maxwell, 2014, Refinancing risk and cash holdings, *The Journal of Finance* 69, 975–1012.

Kaminska, Iryna, Alex Kontoghiorghes, and Walker Ray, 2024, QT versus QE: Who is in when the central bank is out?, Working Paper.

Koijen, Ralph S.J., François Koulischer, Benoît Nguyen, and Motohiro Yogo, 2021, Inspecting the mechanism of quantitative easing in the euro area, *Journal of Financial Economics* 140, 1–20.

Koijen, Ralph S. J., François Koulischer, Benoît Nguyen, and Motohiro Yogo, 2017, Euro-area quantitative easing and portfolio rebalancing, *American Economic Review* 107, 621–27.

Krisnamurthy, Arvind, and Annette Vissing-Jorgensen, 2015, The impact of treasury supply on financial sector lending and stability, *Journal of Financial Economics* 118, 571–600.

Modigliani, Franco, and Richard Sutch, 1966, Innovations in interest rate policy, *The American Economic Review* 56, 178–197.

Myers, Stewart C., 1977, Determinants of corporate borrowing, *Journal of Financial Economics* 5, 147–175.

Selgrad, Julia, 2023, Testing the portfolio rebalancing channel of quantitative easing, *New York University working paper*.

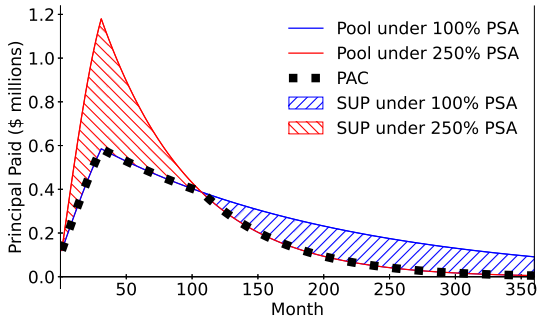
Stanton, Richard, and Nancy Wallace, 1998, Mortgage choice: What's the point?, *Real Estate Economics* 26, 173–205.

Vayanos, Dimitri, and Jean-Luc Vila, 2021, A preferred-habitat model of the term structure of interest rates, *Econometrica* 89, 77–112.

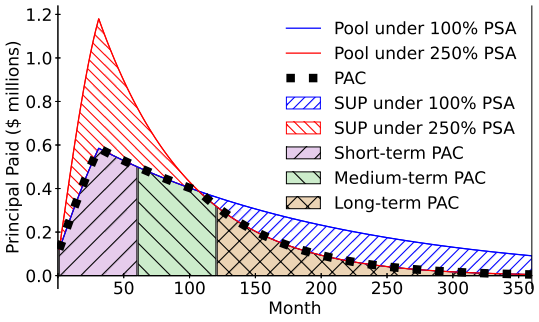
Wiliams, John, 2014, Monetary policy at the zero lower bound: Putting theory into practice, *in Hutchins Center on Fiscal and Monetary Policy (Brookings Institution)*.

Figure 1: **Principal Cash Flows for PACs, SUPs, and SEQs.**
Panel A shows the principal cash flows of a PAC with 100% to 250% PSA bands and its SUP under 100% and 250% PSA prepayment scenarios. Panel B displays the cash flows of three PACs with different average lives and with bands equal to 100% to 250% PSA. These PACs pay the principal amount at the top of each colored (hatched) area. Panel C illustrates the cash flows of three SEQs under a 250% PSA scenario, with the line above the colored (hatched) areas indicating each SEQ's principal cash flows. Panel D shows the cash flows of the same SEQs as in Panel C under a 100% PSA scenario, with the line above the colored (hatched) areas indicating each SEQ's principal cash flows. All figures assume a $100 million unpaid principal at time zero.

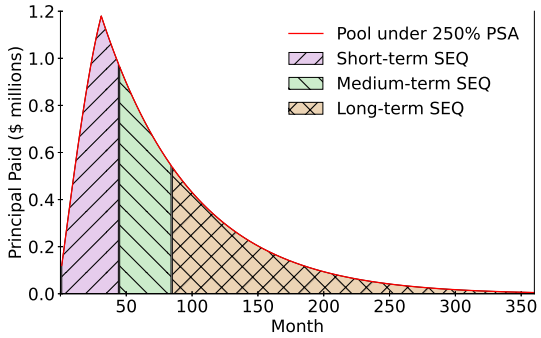
(a) PAC and SUP Tranches



(b) Varied Life PACs



(c) Varied Life SEQs (250% PSA)



(d) Varied Life SEQs (100% PSA)

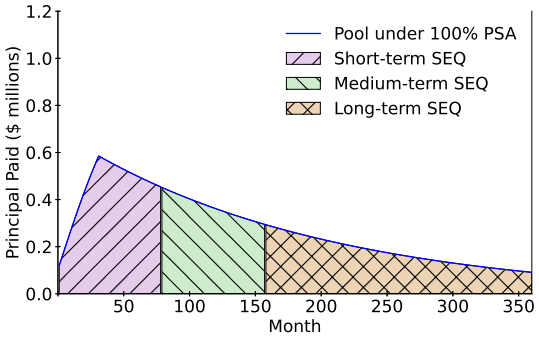
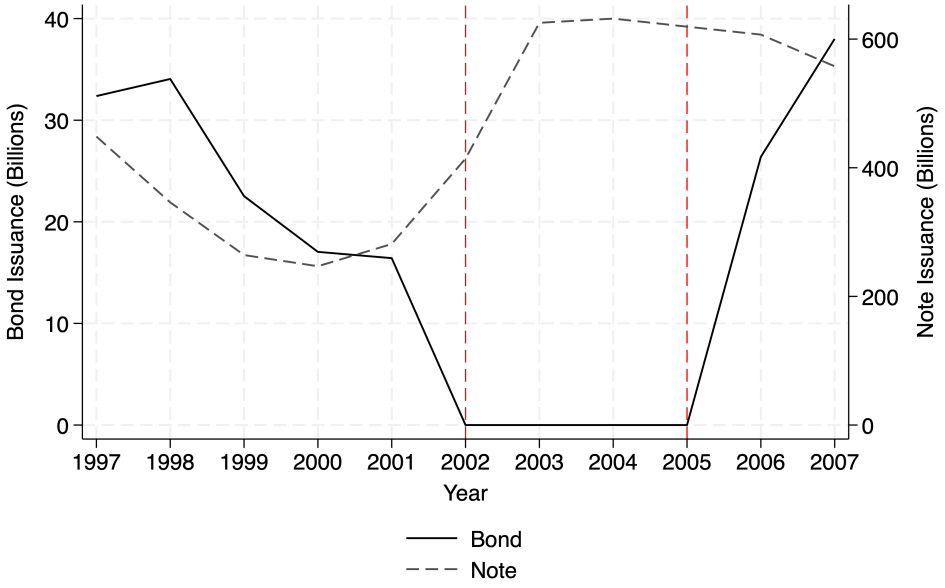
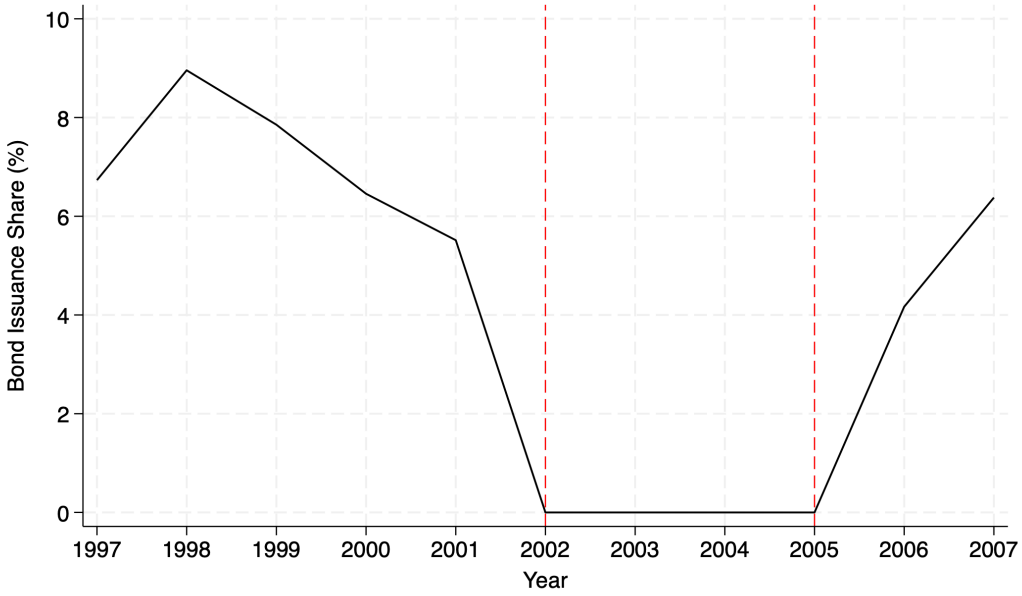


Figure 2: **Total amount of UST Notes and Bonds Issued by Year.**
Panel A shows the yearly total issuance of UST notes (maturity 2 to 10 years) and bonds (maturity over 10 years). Panel B shows the yearly bond issuance as a fraction of total notes and bonds. No UST bonds were issued from 2002 to 2005. The red (dashed) vertical lines represent boundaries of the no-auction period. The suspension of UST bond auctions was announced on Oct. 31, 2001. On May 4, 2005, the U.S. Treasury announced a possible resumption, confirmed on Aug. 3, 2005, for Feb. 2006. For each Treasury CUSIP, we capture the initial issuance and reopenings using *TDTOTOUT* from CRSP.



(a) Gross Issuance of Notes and Bonds



(b) Bond Issuance as Fraction of Total Note and Bond Issuance

Figure 3: **Effect of UST Bond Auction Interruption on PAC Purchases.**
This figure shows that life insurers purchased more newly issued long-term PACs compared to medium-term PACs when 30-year UST bond auctions were suspended. It plots the dynamics of Column (1) in Table 3. The dependent variable is the aggregate value (in millions) of purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) PACs by insurer j in quarter q. We aggregate these purchases separately, resulting in two observations i per quarter q for insurer j. Medium-term PACs have a weighted-average life (WAL) of 2 to 10 years, and long-term PACs have a WAL of more than 10 years, mimicking UST notes and bonds, respectively. The plot shows the coefficients on the interactions of $\mathbb{1}(\text{LT})_{i,j}$ with quarter dummies. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term ($i = 1$) PACs and zero for medium-term ($i = 0$) PACs. We control for insurer j's purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) SEQs in quarter q ($SEQ_{i,j,q}$) to account for time-varying firm-specific factors affecting demand for medium- and long-term CMOs in general. We include insurance company and quarter fixed effects to control for fixed differences between insurers and aggregate trends. The red (dashed) vertical lines denote the $\mathbb{1}(\text{No Auction})_q$ period from 2001 Q4 (30-year UST suspension) to 2005 Q4 (resumption announcement). The coefficient of 18.0 in 2002 Q3 indicates an average increase of $18.0 million in quarterly purchases of newly issued long-term PACs relative to medium-term PACs, accounting for SEQs and fixed effects. We double cluster standard errors by insurer and quarter. We show the 90% confidence intervals. The baseline omitted interaction is 2007 Q4.

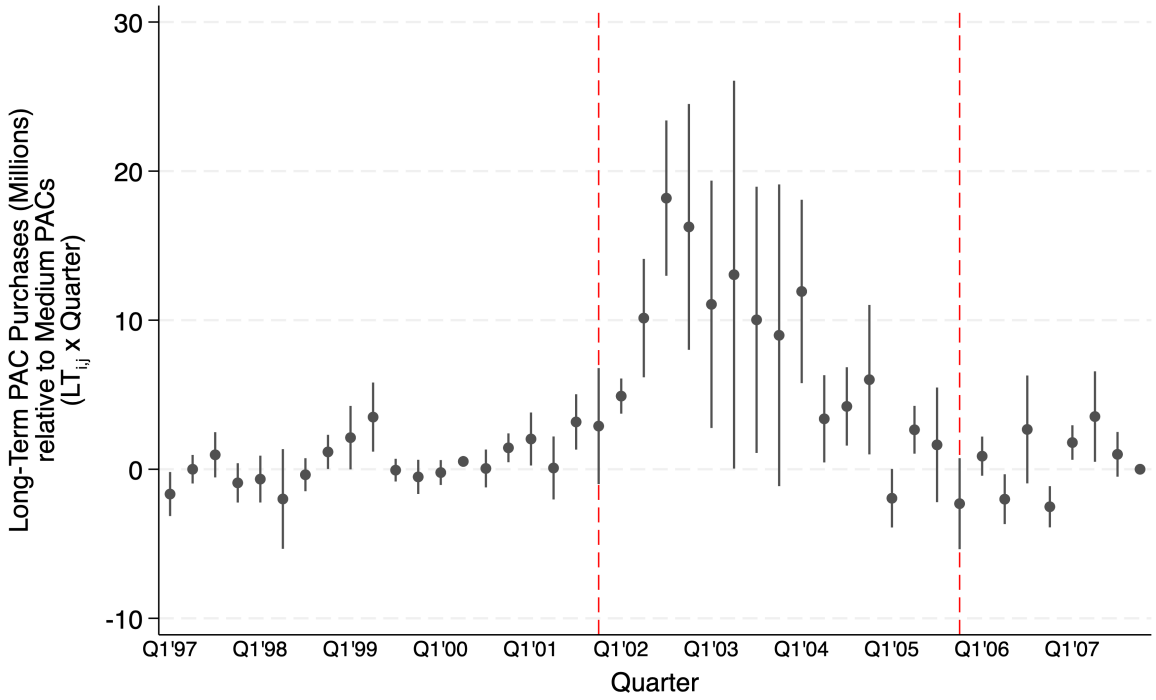
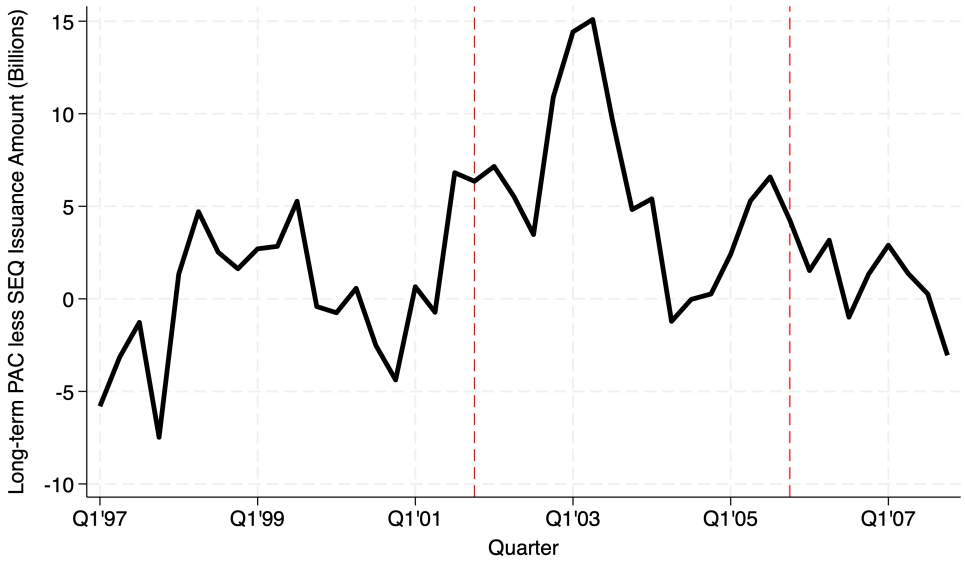
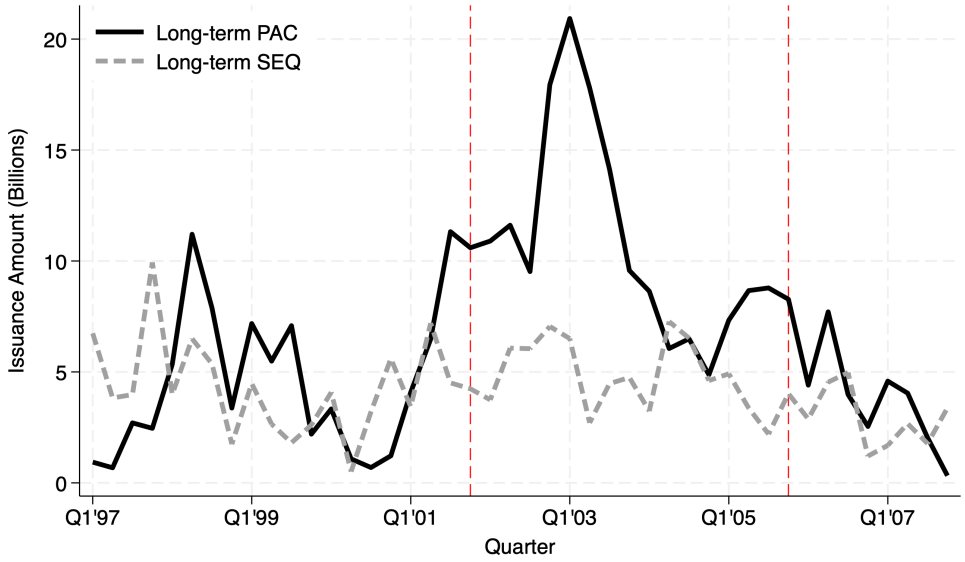


Figure 4: **UST Bond Auction Suspension & Long-term PAC vs SEQ Issuance.** This figure shows an increase in long-term PAC tranche issuance relative to long-term SEQ tranche issuance. In Panel A, the dependent variable is the difference in the aggregate value (in billions) of long-term PAC tranches in quarter q and the aggregate value of long-term SEQs. In Panel B, we separately report the issuance of both long-term PACs and SEQs. The red (dashed) vertical lines denote the $\mathbb{1}(\text{No Auction})_q$ period from 2001 Q4 (30-year UST bond auction suspension) to 2005 Q4 (quarter prior to auction resumption).

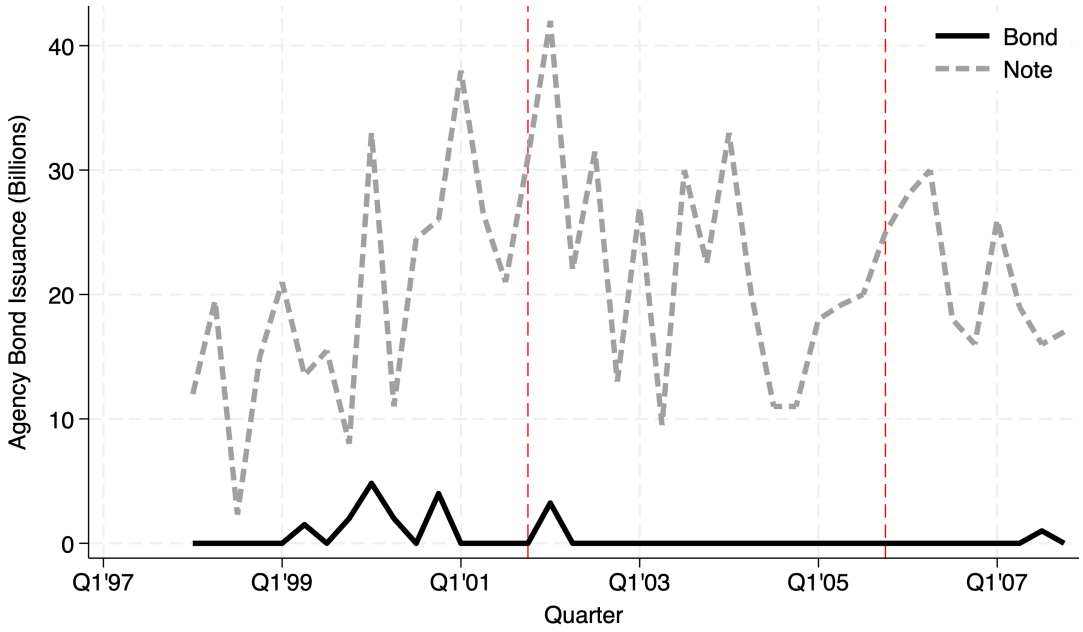


(a) Difference in Long-term PAC and SEQ Issuance

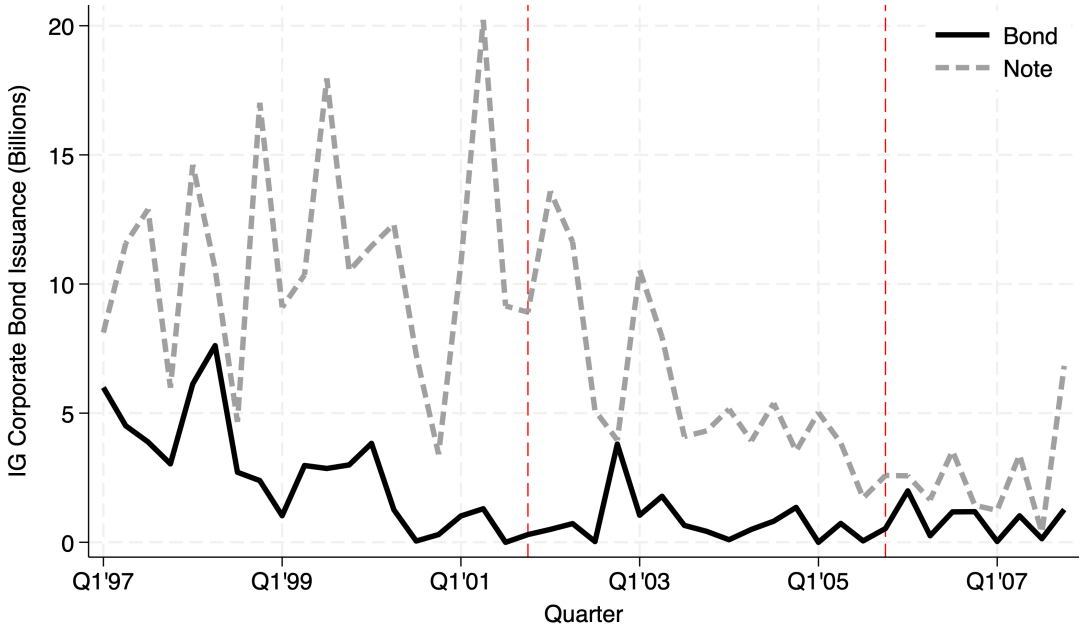


(b) Long-term PAC and SEQ Issuance

Figure 5: Panel A presents the aggregate issuance of Freddie Mac and Fannie Mae benchmark bonds. Introduced in 1998, these non-redeemable bonds serve as reference securities for other fixed-income instruments. They typically have larger issuance sizes, longer maturities, and high liquidity, making them particularly attractive to institutional investors. Panel B reports the issuance of investment-grade corporate bonds. The sample is restricted to straight, fixed-rate corporate bonds, excluding issuances by foreign and financial firms.



(a) Freddie and Fannie Benchmark Bonds



(b) IG Corporate Bonds

Figure 6: **Daily UST Returns & the Suspension Announcement.**
The figure displays the daily return difference between the on-the-run 30-year UST bond and the on-the-run 10-year UST note. Daily returns are calculated as the price change plus accrued and paid interest, divided by the previous day's price plus accrued interest (TDRETNUA in CRSP). Data points are circled for Oct. 31, 2001 (discontinuation of 30-year UST bond auctions) and May 4, 2005 (announcement of possible resumption of UST bond auctions). We annotate other points in Figure A2.

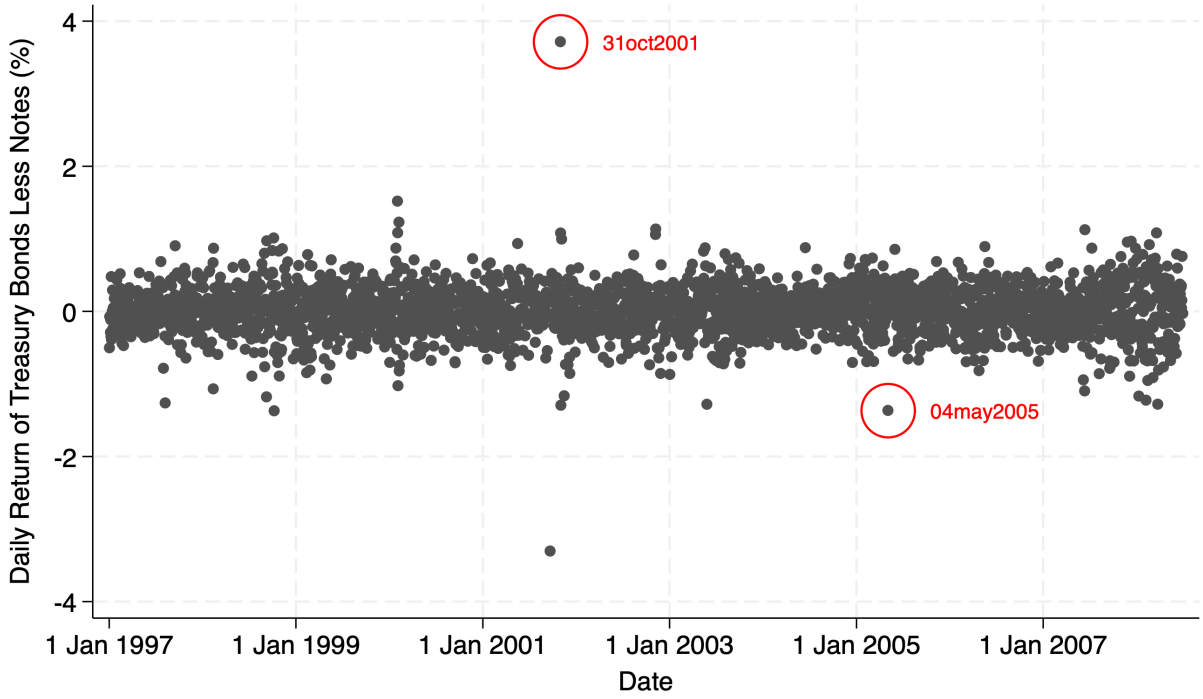


Figure 7: **Monthly PAC Returns and the Suspension.**
This figure shows the monthly difference in returns for long-duration (duration greater than 9 years) and medium-duration (duration of 7-8 years) agency PAC bonds. Medium-duration PAC bonds have a duration similar to that of the 10-year UST note. We circled Oct. 2001 (suspension of 30-year UST bond auctions) and May 2005 (possible resumption of UST bond auctions).

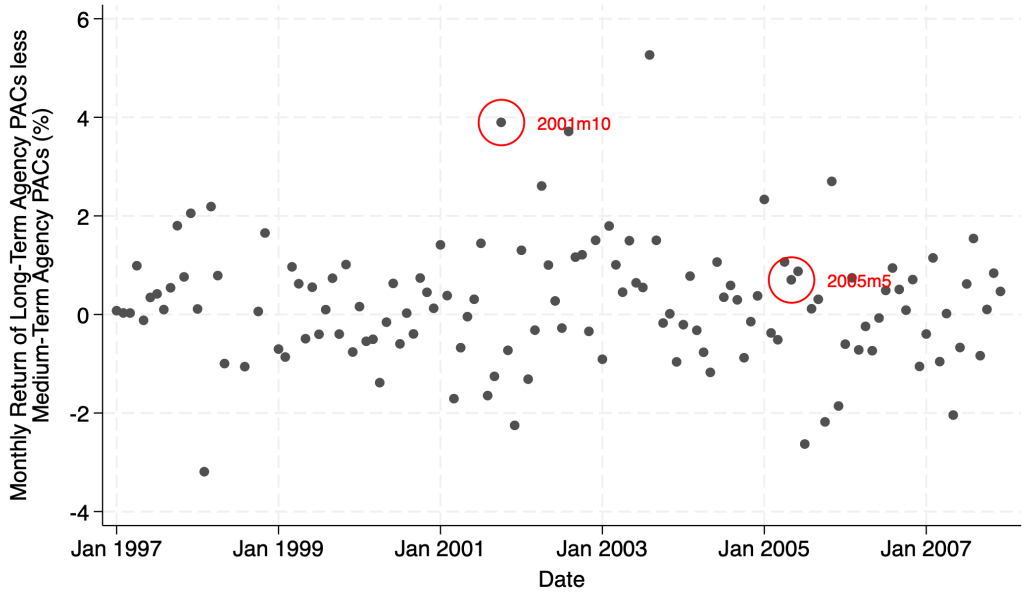


Table 1: **Summary Statistics.**
This table presents summary statistics for CMO issuances from 1997 Q1 to 2007 Q4, winsorized at the 1% level. Panel A reports deal-level statistics, including total issuance and the number of tranches per deal. Panel B presents tranche-level statistics for PAC/SUP tranches, including tranche amount and weighted average life at issuance. Panel C reports similar statistics for SEQ tranches. All monetary values are in millions of U.S. dollars.

	Mean	St. Dev.	Q1	Median	Q3	N
A - CMO Deals						
Total Issuance (Million $)	2,299.5	2,999.6	643.4	1,319.2	2,703.6	3,325
Number of Tranches	44.7	38.1	18	35	59	3,325
B - PAC/SUP Tranches						
Tranche Amount (Million $)	46	63	8	25	57	60,715
Weighted Average Life at Issuance	7.7	5.8	3.3	6.0	11.0	60,715
C - SEQ Tranches						
Tranche Amount (Million $)	72	93	13	34	97	27,716
Weighted Average Life at Issuance	7.8	5.4	3.7	5.4	11.2	27,716

Table 2: **Summary Statistics of Insurers' Purchases of USTs and CMOs.**
This table shows the number (N) of insurer-quarters with purchases of newly issued bonds by type from 1997 Q1 to 2007 Q4 for the 250 largest life insurers and 250 largest property and casualty (P&C) insurers (as of 1999). And, conditional on a quarter with purchases, the table shows the total amounts of such bonds purchased. Medium-term USTs and CMOs have an average life of 2-10 years, while long-term bonds exceed 10 years. Estimates are in millions of dollars. We also show purchases as a percentage of the prior year's fixed income portfolio. For life insurers, there are 9,984 firm-quarters in the final sample. For example, life insurers purchased newly issued long-term PACs in 12.5% (1,251/9,984) of firm-quarters. For P&C insurers, there are 10,644 firm-quarters in the final sample. P&C insurers purchased newly issued long-term PACs in 5.0% (533/10,644) of firm-quarters. We winsorize purchases scaled by AUM at the 5% level to reduce outliers. Winsorizing unscaled purchases would eliminate large firms, but results are robust to both approaches.

	Life Insurers				P&C Insurers			
Panel A: PACs								
	Mean	St. Dev.	Median	N	Mean	St. Dev.	Median	N
Medium Term	30.9	61.8	12.2	938	17.0	25.6	9.2	714
Long Term	45.5	83.3	16.9	1,251	18.0	25.1	10.0	533
% Medium Term	0.6	0.8	0.3	938	1.1	1.2	0.6	714
% Long Term	0.7	0.9	0.4	1,251	1.0	1.1	0.6	533
Panel B: USTs								
	Mean	St. Dev.	Median	N	Mean	St. Dev.	Median	N
Medium Term	43.6	111.7	7.5	1,987	36.5	85.2	8.0	1,943
Long Term	44.8	108.8	9.1	355	18.5	53.0	5.1	172
% Medium Term	0.6	0.9	0.2	1,987	2.3	4.3	0.7	1,943
% Long Term	0.5	0.7	0.2	355	1.1	1.6	0.5	172
Panel C: SEQs								
	Mean	St. Dev.	Median	N	Mean	St. Dev.	Median	N
Medium Term	25.6	42.7	11.0	958	11.5	16.5	5.0	475
Long Term	33.4	52.8	13.6	1,146	14.6	19.2	7.0	344
% Medium Term	0.4	0.5	0.2	958	0.6	0.6	0.4	475
% Long Term	0.5	0.6	0.3	1,146	0.6	0.7	0.4	344

Table 3: **Halted UST Bond Auctions & PAC Purchases by Life and P&C Insurers.** Panel A shows that life insurers purchased more newly-issued long-term PACs relative to medium-term PACs during the suspension of 30-year UST bond auctions. Panel B shows that P&C insurers did not purchase more long-term PACs. In Column (1), the dependent variable is the aggregate value (in millions) of purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) PACs by insurer j in quarter q, resulting in two observations i per quarter q for insurer j. Medium-term PACs have a weighted-average life (WAL) between 2 and 10 years, and long-term PACs have a WAL of more than 10 years. In Column (2), we aggregate purchases of newly issued medium-term and long-term USTs, where a UST's WAL is its time to maturity. In Column (3), we aggregate purchases of newly issued medium-term and long-term Sequential CMOs (SEQs). In Columns (4) to (6), we repeat Columns (1) to (3) after scaling by the insurer's fixed income portfolio size at the end of year $y-1$. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term ($i = 1$) securities and zero for medium-term ($i = 0$) securities. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. We control for insurer j's purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) SEQs in quarter q ($SEQ_{i,j,q}$) to account for time-varying firm-specific factors affecting insurer j's demand for medium- and long-term CMOs. We include insurance company and quarter fixed effects to control for insurer-specific and aggregate trends. We double cluster standard errors by quarter and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Panel A: Life Insurers (Preferred Habitat Investors)

	$\text{PACs}_{i,j,q}$	$\text{UST}_{i,j,q}$	$\text{SEQs}_{i,j,q}$	$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\frac{\text{UST}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_q$	6.78**	-12.46*	-1.04	0.06***	-0.07*	-0.00
	(3.25)	(7.09)	(1.59)	(0.02)	(0.04)	(0.01)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q$	0.23	-1.93	-0.30	-0.01	0.00	-0.01
	(0.96)	(2.54)	(0.59)	(0.01)	(0.02)	(0.01)
$\mathbb{1}(\text{LT})_{i,j}$	0.21	-4.29***	1.65**	0.01	-0.08***	0.02***
	(0.50)	(1.20)	(0.62)	(0.01)	(0.02)	(0.01)
$\text{SEQs}_{i,j,q}$	0.45***					
	(0.16)					
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$				0.29***		
				(0.04)		
Constant	1.66*	11.12***	2.83***	0.05***	0.12***	0.04***
	(0.94)	(1.34)	(0.47)	(0.01)	(0.01)	(0.00)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	23.64	12.32	19.48	12.46	11.77	9.40
# Insurers	250	250	250	250	250	250
# Quarters	44	44	44	44	44	44
# Observations	19960	19960	19960	19960	19960	19960

Panel B: Property & Casualty Insurers (Non-Preferred Habitat Investors)

	$\text{PACs}_{i,j,q}$	$\text{UST}_{i,j,q}$	$\text{SEQs}_{i,j,q}$	$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\frac{\text{UST}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_q$	-0.46	-6.22**	-0.21	-0.02	-0.23*	-0.02***
	(0.43)	(2.99)	(0.16)	(0.02)	(0.13)	(0.01)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q$	-0.54*	-3.77	-0.23*	0.00	0.01	-0.01*
	(0.31)	(4.60)	(0.12)	(0.01)	(0.14)	(0.01)
$\mathbb{1}(\text{LT})_{i,j}$	0.09	-4.41***	0.08	-0.02	-0.32***	0.01
	(0.11)	(1.23)	(0.08)	(0.01)	(0.07)	(0.00)
$\text{SEQs}_{i,j,q}$	0.24***					
	(0.04)					
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$				0.15***		
				(0.04)		
Constant	1.06***	7.76***	0.53***	0.07***	0.43***	0.03***
	(0.09)	(0.79)	(0.04)	(0.00)	(0.03)	(0.00)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	7.90	8.41	12.60	6.13	7.46	4.76
# Insurers	250	250	250	250	250	250
# Quarters	44	44	44	44	44	44
# Observations	21288	21288	21288	21288	21288	21288

Table 4: **Fewer Long-Term USTs, More Long-Term PAC Purchases: 1995–2023**
Panel A illustrates that from 1995 to 2023, as the time-to-maturity of Treasury debt issuances shortens, life insurers increasingly allocate their investments toward long-term PACs rather than medium-term PACs and other CMOs with prepayment risk. In contrast, Panel B demonstrates no such relation exists for P&C insurers. *WAM UST*$_q$ is the weighted average maturity of Treasury issuances in quarter q, using issuance amounts as weights. Maturities are measured from the issuance date. For reopened issuances, we calculate maturities from the reopening date. The weighted average maturity for quarter q is the sum of each issuance's amount multiplied by its maturity at issuance, divided by the total issuance amount in that quarter. In columns (3) and (6), we instrument *WAM UST*$_q$ with the ratio of total UST outstanding in quarter q to GDP in quarter q. The first stage F-statistics are both above 10,000, exceeding the Stock-Yogo critical value of 10, indicating that the instrument is not weak. We include insurance company and quarter fixed effects to control for insurer-specific and aggregate trends. We report standard errors clustered at the insurer and quarter levels. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively.

Panel A: Life Insurers (Preferred Habitat Investors)

	$\text{PACs}_{i,j,q}$			$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$		
	OLS	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times$ WAM UST_q	-2.01***	-0.91***	-2.77***	-0.03***	-0.01*	-0.04***
	(0.67)	(0.33)	(0.78)	(0.01)	(0.01)	(0.01)
$\mathbb{1}(\text{LT})_{i,j}$	4.07***	1.85***	5.27***	0.06***	0.02*	0.08***
	(1.30)	(0.63)	(1.47)	(0.02)	(0.01)	(0.02)
$\text{SEQs}_{i,j,q}$	0.33***	0.23***	0.33***			
	(0.06)	(0.05)	(0.06)			
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$				0.25***	0.22***	0.25***
				(0.03)	(0.05)	(0.03)
Excl. Suspension & Crisis	No	Yes	No	No	Yes	No
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	20.62	16.13	9.36	10.77	9.23	3.35
# Insurers	250	250	250	250	250	250
# Quarters	116	84	116	116	84	116
# Observations	46600	33376	46600	46600	33376	46600

Panel B: Property & Casualty Insurers (Non-Preferred Habitat Investors)

	$\text{PACs}_{i,j,q}$			$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$		
	OLS	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times$ WAM UST_q	0.04	-0.27	0.10	0.00	-0.02	0.02
	(0.17)	(0.20)	(0.21)	(0.01)	(0.01)	(0.01)
$\mathbb{1}(\text{LT})_{i,j}$	-0.22	0.36	-0.31	-0.02	0.02	-0.04*
	(0.34)	(0.39)	(0.39)	(0.02)	(0.02)	(0.02)
$\text{SEQs}_{i,j,q}$	0.15***	0.09***	0.15***			
	(0.04)	(0.03)	(0.04)			
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$				0.08***	0.05**	0.09***
				(0.02)	(0.02)	(0.02)
Excl. Suspension & Crisis	No	Yes	No	No	Yes	No
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	8.05	6.70	2.25	4.51	4.12	0.41
# Insurers	250	250	250	250	250	250
# Quarters	116	84	116	116	84	116
# Observations	53080	38016	53080	53080	38016	53080

Table 5: **Suspended UST Bond Auctions & Long-term PAC vs SEQ Issuance.**
In Column (1), the dependent variable is the aggregate amount of long-term PAC or SEQ issuance (in billions), and in Column (2), it is its natural logarithm. The results show that long-term PAC issuance increased during the UST suspension period versus long-term SEQ issuance. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. Standard errors are clustered at the quarter level, and quarter fixed effects are included, absorbing the standalone $\mathbb{1}(\text{No Auction})_q$ and $\mathbb{1}(\text{Post Period})_q$ variables. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Billions	Log
	(1)	(2)
$\mathbb{1}(\text{No Auction})_q \times$ Long-term PAC_i	5.77***	0.92***
	(1.41)	(0.26)
$\mathbb{1}(\text{Post Period})_q \times$ Long-term PAC_i	0.68	0.23
	(1.11)	(0.43)
Long-term PAC_i	0.13	-0.14
	(0.85)	(0.23)
Constant	4.25***	22.05***
	(0.29)	(0.07)
Quarter FE	Yes	Yes
% Adjusted R^2	49.4	38.9
# Observations	88	88

Table 6: **Suspended UST Bond Auctions & Corporate/Agency Bond Issuances.** In Column (1), the dependent variable represents the total issuance of benchmark agency bonds by Fannie Mae and Freddie Mac. These benchmark bonds, introduced in 1998, are non-redeemable and serve as a reference point for other fixed-income securities. They typically feature larger issuance sizes, longer maturities, and high liquidity, making them attractive to institutional investors. The introduction of these bonds in 1998 results in eight fewer observations relative to corporate bonds in Columns (3) and (4). Column (1) reports values in billions, while Column (2) presents the natural logarithm of the issuance amount in billions plus one to account for quarters with no long-term agency bond issuances. In Column (3), the dependent variable is the total issuance of investment-grade corporate debt per quarter, measured in billions. The sample is restricted to USD-denominated corporate bond offerings by U.S.-domiciled non-financial firms from 1997 to 2007. These bonds must be non-redeemable, non-putable, non-convertible, non-exchangeable, and fixed-rate debt instruments to be included in the sample. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. Standard errors are clustered at the quarter level, and quarter fixed effects are included, absorbing the standalone $\mathbb{1}(\text{No Auction})_q$ and $\mathbb{1}(\text{Post Period})_q$ variables. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Agency		IG Corporate	
	Billions	Log(1+Y)	Billions	Log(1+Y)
	(1)	(2)	(3)	(4)
$\mathbb{1}(\text{No Auction})_q \times \mathbb{1}(\text{Long Term})_i$	-4.33	-0.58**	2.94**	-0.11
	(3.20)	(0.24)	(1.36)	(0.20)
$\mathbb{1}(\text{Post Period})_q \times \mathbb{1}(\text{Long Term})_i$	-2.96	-0.56**	6.37***	0.64***
	(3.16)	(0.26)	(1.22)	(0.20)
$\mathbb{1}(\text{Long Term})_i$	-18.17***	-2.43***	-8.11***	-1.24***
	(2.41)	(0.22)	(1.06)	(0.15)
Constant	21.06***	3.00***	7.51***	1.96***
	0.94	(0.07)	(0.41)	(0.06)
Quarter FE	Yes	Yes	Yes	Yes
% Adjusted R^2	75.4	91.3	66.8	76.7
# Observations	80	80	88	88

Table 7: **Fewer Long-Term USTs, More Long-Term PAC Issuance: 1995–2023**
This table demonstrates that as the time-to-maturity of Treasury debt issuances shortens, mortgage dealers create more long-term PAC CMOs relative to total long-term PAC and SEQ CMOs. In column (5), the dependent variable is the natural logarithm of this ratio to examine elasticities. *WAM UST*$_q$ is the weighted average maturity of Treasury issuances in quarter q, using issuance amounts as weights. Maturities are measured from the issuance date. For reopened issuances, we calculate maturities from the reopening date. The weighted average maturity for quarter q is the sum of each issuance's amount multiplied by its maturity at issuance, divided by the total issuance amount in that quarter. *FF Rate*$_q$ is the 1-month federal funds rate futures, while *FF Rate Spread*$_q$ is the difference between the 9-month and 1-month federal funds rate futures, controlling for market expectations regarding interest rate reductions and mortgage refinancing. *Term Spread*$_q$ is the yield difference between 30-year and 1-year Treasury securities. *IG Credit Spr*$_q$ is the spread between Moody's Baa corporate bond yield and the 30-year Treasury yield, indicating credit risk. *Linear Trend*$_q$ captures time trends per quarter. *Refi Index*$_q$ is the Mortgage Bankers Association (MBA) Refinancing Index, normalized by dividing by 10,000 for easier interpretation. Business cycle controls include four leads and lags of an NBER recession indicator. In column (3), we exclude the suspension years 2002–2005 and the crisis years 2008–2010. In columns (4), we instrument *WAM UST*$_q$ using total UST outstanding relative to GDP. First-stage F-statistics (76.4) exceed the Stock-Yogo threshold of 10, confirming instrument strength. We report Newey-West standard errors with four-quarter lags to correct for autocorrelation and heteroskedasticity. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively.

	Y=LT PAC/(LT PAC+LT SEQ) Tranche Issuance$_q$				
	Y	Y	Y	Y	Ln(Y)
	OLS	OLS	OLS	IV	OLS
	(1)	(2)	(3)	(4)	(5)
WAM UST	-0.19***	-0.21***	-0.19***	-0.49***	
	(0.05)	(0.05)	(0.06)	(0.10)	
Ln(WAM UST)					-0.57**
					(0.23)
FF Rate		0.06***	0.03	0.10***	0.48***
		(0.02)	(0.03)	(0.04)	(0.12)
FF Spread		0.07	0.04	0.15**	0.21
		(0.05)	(0.06)	(0.07)	(0.23)
Term Spread		-0.02	0.01	-0.03	-0.28**
		(0.04)	(0.04)	(0.04)	(0.14)
IG Credit Spr		0.04	0.14**	0.07	0.12
		(0.05)	(0.07)	(0.05)	(0.15)
Linear Trend		-0.00***	-0.00***	-0.00**	-0.03***
		(0.00)	(0.00)	(0.00)	(0.01)
Refi Index		0.20	0.38	-0.18	0.35
		(0.14)	(0.27)	(0.19)	(0.48)
Constant	0.69***	-4.72**	-1.99	-8.19**	-41.78***
	(0.09)	(2.17)	(2.25)	(3.39)	(10.62)
No Suspension/Crisis	No	No	Yes	No	No
Bus. Cycle Ctrls	No	Yes	Yes	Yes	Yes
% Adjusted R^2	16.90	43.54	27.75	20.43	43.50
# Observations	116	116	84	116	116

Table 8: **Halted UST Bond Auctions & the Returns of Bonds and PACs.**
This table examines the returns of UST bonds, PAC CMOs, and fed funds futures contracts around the U.S. Treasury's October 31, 2001 announcement suspending 30-year Treasury bond auctions. Daily on-the-run UST returns for bonds and notes are sourced from CRSP, monthly PAC returns are obtained from the ICE Bank of America Merrill Lynch CMO Indices, daily fed fund futures prices come from Bloomberg, and the yields of the on-the-run USTs are from Federal Reserve Economic Data (FRED). UST returns are calculated as the price change plus accrued and paid interest, divided by the previous day's price plus accrued interest (TDRETNUA in CRSP). We compute the daily return differential between the on-the-run 30-year UST bond and the on-the-run 10-year UST note. Panel A reports the daily return of the on-the-run 30-year UST bond, while Panel B presents the change in yield. Panel C examines the monthly returns of the 30-year UST bond and PAC CMOs, calculated from the closing value at the end of the previous month to the closing value at the end of the current month. For PACs, we compute the monthly difference in value-weighted average returns (TRRMTD in ICE Index) for agency PAC bonds with long (9+ years) and medium (7-8 years) durations, with medium-duration PAC bonds having a duration comparable to the 10-year UST note. The monthly returns around the May 4, 2005, reversal announcement are measured from the close on April 30, 2005, to the close on May 31, 2005. Panel D analyzes the daily changes in the prices of 30-day fed funds futures (FF1, FF6, and FF9) from Bloomberg, which mature in one, six, and nine months, respectively. Futures contracts with longer maturities are unavailable for this sample period. Column (2) displays the t-statistic relative to the prior distribution (January 1, 1997, to August 30, 2001). Columns (3) and (4) report the return difference and t-statistic for the potential reversal announcement on May 4, 2005. ***, **, and * denote statistical significance at 1%, 5%, and 10%, respectively.

	Suspension Announced (Oct 31, 2001)		Possible Reversal Announced (May 4, 2005)	
	Effect	t-stat	Effect	t-stat
	(1)	(2)	(3)	(4)
Panel A: Daily Returns				
Treasury Bond Returns	5.10***	8.6	-1.53**	-2.6
Treasury Bond Less Note Returns	3.72***	13.7	-1.37***	-5.0
Panel B: Daily Yield Changes				
Treasury Bond	-0.33***	-6.0	0.11**	2.0
Treasury Bond Less Note	-0.19***	-9.3	0.12***	5.9
Panel C: Monthly UST and PAC Returns				
Treasury Bond Returns	6.04***	2.9	2.65	1.1
Treasury Bond Less Note Returns	5.71***	5.2	1.21	1.0
Long PAC Bond Return	5.00**	2.1	2.58	0.9
Long Less Medium PAC Returns	3.90***	4.3	0.70	0.7
Panel D: Daily Fed Fund Futures Prices				
Fed Fund Futures, $t+1$	0.00	-0.1	0.00	-0.1
Fed Fund Futures, $t+6$	-0.02	-0.6	0.04	1.2
Fed Fund Futures, $t+9$	0.01	0.2	0.05	1.4

Internet Appendix to
Identifying the Portfolio Balance Mechanism

This Internet Appendix contains supplementary analyses. These include the following:

1. Appendix A.1 contains a brief explanation of the PSA standard.
2. Appendix A.2 contains model details
3. Appendix A.3 provides additional data descriptions.
4. Appendix A.4 describes additional analysis supporting identification
5. Figure A1 shows the collateral supporting PAC issuance vs SEQ issuance.
6. Figure A2 fully annotates Figure 6.
7. Figure A3 shows the cumulative residual returns and yield changes for 30-year bonds relative to the rest of the yield curve.
8. Figure A4 shows the monthly returns of agency SUP bonds.
9. Figure A5 shows the principal cash flows of a mortgage pass-through under different prepayment speeds.
10. Figure A6 shows the number of life insurers and total AUM by year.
11. Figure A7 shows Treasury yield spreads: 1997-2007 by WAL.
12. Figure A8 shows the federal funds rate during different periods: (a) Placebo Period 1 (2006-2016), (b) Placebo Period 2 (2018-2023), and (c) Main Sample Period (1997-2007).
13. Table A1 shows the fixed income holdings for the top 250 life and top 250 P&C insurers in 1999 by type.
14. Table A2 shows the Table 3 results are robust to using a log transformation.
15. Table A3 shows the Table 3 results are robust to using a narrower range of WAL to define medium-term bonds ($5 \leq \text{WAL} \leq 10$).
16. Table A4 shows the Table 3 results are robust to including secondary market purchases.
17. Table A5 shows the effect is strongest for the safest PAC types.
18. Table A6 shows that increase in PAC demand is not limited to a few large insurers.
19. Table A7 examines life insurers' PAC purchases during two placebo periods with interest rate drops like in 2001.

20. Table A8 shows that Table 4 is robust to using the proportion of UST issuances that are long-term with WALs exceeding 10 years.

21. Table A9 shows the amount of pass-through collateral tranched into PACs and SEQs.

22. Table A10 shows life insurers' purchases of corporate and agency bonds.

23. Table A11 shows Table 7 is robust to using the proportion of UST issuances that are long-term with WALs exceeding 10 years.

24. Table A12 shows collateral allocated to PAC versus SEQs, 1997-2023.

25. Table A13 shows the relationship between long-term PAC bond returns and 30-Year UST returns.

26. Table A14 presents the regressions used to compute the residual returns and daily yield changes in Figure A3.

A.1 PSA Standard

Prepayments have a significant effect on the cash flows of pass-through securities. Prepayment speeds are typically defined in terms of the Bond Market Association's prepayment speed standard (PSA). The PSA standard is commonly used as a simple metric to build different prepayment speed scenarios. Recently originated mortgages are less likely to prepay than seasoned mortgages. This seasoning effect on prepayments is captured in the PSA standard. This standard assumes that the annualized principal prepayment rate of a pool of mortgages is equal to 0.2% for one-month old mortgages, increases by 0.2% every month until it reaches 6% for mortgages 30-months old, remaining constant at 6% until the mortgages are paid in full. Figure A5 shows the principal cash flows of a pass-through under three different PSA scenarios.[37] In all three scenarios, the principal cash flows are at the maximum level when the underlying mortgage pool is 30-months old. This is a natural consequence of the PSA prepayment speeds. In addition, this creates the hump-shaped pattern that is common in all three scenarios. With 200% PSA, the principal cash flows of the underlying pool are much higher during the first 120 months of the mortgage pool, so the average life of the pool is shorter compared to that with 100% PSA. In contrast, in the 50% PSA scenario, the principal cash flows are spread more evenly over time. This results in an average life for the pool of mortgages that is longer than the one with 100% PSA due to the extension of the mortgage cash flows.

A.2 Model Details

Our model expands on the framework presented in Greenwood, Hanson, and Stein (2010), adapting it to a scenario with a mortgage dealer. As in Greenwood, Hanson, and Stein (2010), we consider a three-period world. In the first period, the known short-term interest rate is r_1. The interest rate for the second period is r_2 with mean μ_r and variance σ_r^2.

There are two investors holding bonds that mature at $t = 3$. They differ only in their demand elasticities for these long-term bonds. Specifically, the net demand of each investor for these bonds, after accounting for government supply, is given by

$$Z^i = \frac{1}{2}\Big[\alpha^i\Big(\tfrac{1}{P} - (1+r_1)(1+\mu_r)\Big) \; - \; g\Big] \tag{11}$$

where $\alpha^i \geq 0$ is the demand elasticity of investor i and $g \leq 0$ is a constant. The demand for long-term bonds decreases with their price (P) and increases with their excess return, given by $\frac{1}{P} - (1+r_1)(1+\mu_r)$. Investors with a preferred habitat for long-term bonds are denoted as type $i = PH$, while non-preferred-habitat investors are denoted as $i = NPH$. The demand from preferred-habitat investors is less price-elastic ($\alpha^{PH} < \alpha^{NPH}$). The constant $\frac{1}{2}$ ensures that the model coincides with that in Greenwood, Hanson, and Stein (2010). Indeed, when $\alpha^{PH} = \alpha^{NPH} = 0$, both investors are treated as preferred-habitat investors with inelastic demand equal to $-g/2$. This scenario aligns with Greenwood, Hanson, and Stein (2010), where g represents the quantity of bonds issued by the government minus the total demand from price-inelastic preferred-habitat investors.

[37] See https://www.sifma.org/wp-content/uploads/2017/08/chsf.pdf for the formulas used to calculate these cash flows.

Drawing parallels to Greenwood, Hanson, and Stein (2010), our model incorporates a yield curve arbitrageur adept at capitalizing on arbitrage opportunities within the yield curve. This term-structure arbitrageur addresses the excess demand for long-term bonds by selling long-term bonds at a price P and reallocating the proceeds at the short-term interest rate. The arbitrageur maximizes the mean variance utility of terminal wealth:

$$\max_h h[(1+r_1)(1+\mu_r) - \frac{1}{P}] - \frac{h^2}{2}\frac{(1+r_1)^2\sigma_r^2}{\lambda}$$

where λ is the yield curve arbitrageur's risk tolerance. The first order condition of this problem implies:

$$h^* = \frac{(1+r_1)(1+\mu_r) - 1/P}{\eta_h} \tag{12}$$

where $\eta_h = (r_1+1)^2\sigma_r^2/\lambda$ is the risk penalty associated with the yield-curve arbitrageur's problem.

The mortgage dealer addresses the excess demand from preferred habitat investors for bonds maturing at time 3 by issuing Planned Amortization Class (PAC) securities. Specifically, the dealer acquires f dollars worth of mortgage pass-through securities, financed by bonds maturing at time $t = 3$.[38] These bonds, being devoid of prepayment risk, are akin to PACs. The mortgage dealer assumes the prepayment risk for the mortgages financed by these PACs, similar to how a hedge fund would retain a support tranche. The prepayment amount, denoted as (Π_2), is reinvested at the interest rate r_2, while the non-prepaid portion $(1-\Pi_2)$ accrues interest at rate c. Consequently, the mortgage dealer's profit at time t_3, derived from financing mortgages with PACs, is calculated as $f \times (1 + M_I - 1/P)$, where P represents the price of the zero-coupon bond maturing at time 3. Here, $M_I = (1-\Pi_2)c + \Pi_2 r_2 + (1+r_2)c$ signifies the value at time 3 of the interest paid on \$1 of mortgage principal from time 1 to 3. The term M_I has a mean of μ_M and a variance of σ_M^2. Accordingly, the mortgage dealer's wealth at time 3 is expressed as $W = f \times (1 + M_I - 1/P)$. The mortgage dealer's objective is to maximize the mean-variance utility of terminal wealth:

$$\max_f E[W] - \frac{1}{2\theta}\sigma_W^2 \tag{13}$$

Here, θ symbolizes the mortgage dealer's risk tolerance. The primary condition for optimization yields $f = (1 + \mu_M - 1/P)/\eta_f$, with $\eta_f = \sigma_I^2/\theta$ representing the risk penalty inherent to the mortgage dealer's problem.

$$f^* = \frac{1 + \mu_M - 1/P}{\eta_f} \tag{14}$$

The mortgage interest rate c is exogenous to our model. For simplicity, and without loss of generality, we assume that the mortgage rate is determined in the pass-through market in a

[38] For the sake of simplicity, our model does not incorporate short-selling constraints. That is, when the excess supply of bonds is positive ($g > 0$), mortgage dealers are allowed to short sell mortgage pass-throughs for investing in long-term bonds. Our primary focus, however, remains on scenarios where there is a negative excess supply for bonds.

manner that does not price prepayment, i.e., $1+\mu_M = (1+\mu_r)(1+r_1)$, implying that:

$$f^* = \frac{(1+r_1)(1+\mu_r) - 1/P}{\eta_f} \tag{15}$$

The first order conditions of the arbitrageur's and mortgage dealer's problems along with the market clearing condition ($f^* + h^* = Z^{PH} + Z^{NPH}$) result that the 2-period expected excess return of the long-term bond is:

$$\frac{1}{P} - (1+r_1)(1+\mu_r) = \frac{\eta_f \eta_h}{\eta_f + \eta_h + \overline{\alpha}\eta_f\eta_h} g \tag{16}$$

where $\overline{\alpha}$ is the average of α^{PH} and α^{NPH}. Substituting the expression above in the expressions for f^* and h^* results in:

$$f^* = -\frac{\eta_h}{\eta_f + \eta_h + \overline{\alpha}\eta_f\eta_h} g \text{ and } h^* = -\frac{\eta_f}{\eta_f + \eta_h + \overline{\alpha}\eta_f\eta_h} g \tag{17}$$

substituting Equation 16 in Equation 11 results in:

$$Z^{NPH} = -\frac{g}{2}\frac{\eta_f + \eta_h + (\overline{\alpha} - \alpha^{NPH})\eta_f\eta_h}{\eta_f + \eta_h + \overline{\alpha}\eta_f\eta_h} \tag{18}$$

$$Z^{PH} = -\frac{g}{2}\frac{\eta_f + \eta_h + (\overline{\alpha} - \alpha^{PH})\eta_f\eta_h}{\eta_f + \eta_h + \overline{\alpha}\eta_f\eta_h} \tag{19}$$

$$Z^{PH} - Z^{NPH} = -\frac{g}{2}\frac{(\alpha^{NPH} - \alpha^{PH})\eta_f\eta_h}{\eta_f + \eta_h + \overline{\alpha}\eta_f\eta_h} \tag{20}$$

A.3 Data Details

Our empirical analysis of the suspension and resumption of the 30-year UST bond spans from 1997 Q1 to 2007 Q4, beginning in 1997 Q1 because of the availability of CMO pricing data, and concluding in 2007 Q4 to ensure that our findings are not influenced by the 2008 financial crisis.

We gather data for all non-callable UST bonds and notes trading during our sample period from the CRSP Treasury files. CRSP data contain information on each UST, including CUSIP, daily return, total amount outstanding, issuance date, and maturity date.

Our CMO database is a comprehensive panel of all standard agency-CMOs issued between 1997 Q1 and 2007 Q4 by the Federal Home Loan Mortgage Company (FHLMC "Freddie Mac"), the Federal National Mortgage Association (FNMA "Fannie Mae"), and Government National Mortgage Association (GNMA "Ginnie-Mae"). The data related to FHLMC and FNMA CMOs are from Bloomberg and the data for GNMA CMOs are obtained from the GNMA data disclosure website[39] The raw data consist of 3,325 individual CMO deals with 148,386 individual tranches. A deal can have multiple groups of collateral that are separately tranched to create PACs or SEQs. For each tranche, we have an exhaustive array of char-

[39] https://www.ginniemae.gov/investors/investor_search_tools/Pages/default.aspx

acteristics, including the CUSIP, issue size, and weighted average life (WAL) calculated at the time of issuance based on the benchmark prepayment scenario used in the CMO deal's prospectus. We also have information on the collateral whose cash flows are being tranched.

Using Bloomberg and GNMA classifications of the tranche types, we remove those CMOs that do not fall within the following three classes of tranche types: planned amortization class (PAC), support tranches (SUP), and sequential pay securities (SEQ). Our final database has 3,182 deals and 88,431 CMO tranches, all falling within these three classes of tranches. There are hundreds of CMO types in the data. We remove from our data CMOs such as hybrid CMOs (e.g. IO+PAC) that cannot clearly be assigned to the three classes mentioned above. Specifically, we counted the number of occurrences of the most common types of CMOs which are "PAC", "SEQ", "SUP", "IO", "PO", and "TAC" in the type description. Then, for this set of tranche types, we classified a tranche as a PAC if the term "PAC" is the only term appearing in the type description from this set of types. Likewise, a SEQ tranche only has "SEQ" in the type description. The discarded CMO tranches that we cannot cleanly categorize make up a much smaller fraction of the principal amount of CMOs in the data than PAC, SUP, and SEQ. Arcidiacono, Cordell, Davidson, and Levin (2013) describe the many different types of CMOs.

Our life insurance companies' bond portfolio data are sourced from the National Association of Insurance Commissioners (NAIC) database. Specifically, we use NAIC Schedule D - Part 1 data. These data include details about individual life insurers, such as their end-of-year assets under management (AUM) and bond holdings at the CUSIP level. The initial NAIC data are from 1997 to 2007. We remove years when an insurance company is not active and keep insurers in the top 250 of assets under management in 1999, which predates the shock. Although there are 1,305 insurers in the sample in 1999, the top 250 (100) insurers control 95% (82%) of the fixed income assets or $1.4 ($1.2) trillion. This filter prevents the results from being affected by a large number of companies that have a small portfolio.

Appendix Figure A6 shows the number of life insurance companies by year in our sample. The number of insurers is exactly 250 in 1999 because we limited the sample to the top 250 insurers by AUM in 1999. The figure shows that the number of insurers decreases during the sample period to 203 insurers in 2007. This decrease of 18.8% is in line with the overall decrease in the number of life insurers of 25.1% during the same period of time, as documented by the American Council of Life Insurers (ACLI, 2022). (Table 1.7 of the *Life Insurers Fact Book 2022* shows that the number of life insurers is 1347 in 1999 and 1009 in 2007, a 25.1% decrease.) Figure A6 also shows trends in the aggregate size of the fixed income portfolios of life insurers during the sample period. In 1999, life insurers managed about $1.4 trillion, and in 2007, despite a decline in the number of life insurers in the sample, life insurers managed about $2.1 trillion.

Because some holdings are non-US and not denominated in dollars, we use the reported total AUM of the insurer, which is dollar-denominated. The structure of NAIC data varies annually, necessitating meticulous assembly of multiyear datasets. For example, the line numbers that refer to the total AUM vary from year to year.

To analyze how preferred-habitat investors responded to the interruption of UST bond auctions, we merged our CRSP Treasury data with the CMO data and the NAIC data by CUSIP. The result of merging these three different data sources is a comprehensive database

containing life insurance companies' holdings, along with the characteristics of the USTs and CMOs in their portfolios.

Using these unique merged data, we identify purchases by life insurance companies of newly issued USTs and CMOs, which is fundamental to addressing Hypothesis 1. Although the raw NAIC data do not include the issuance date of the bonds, which is necessary to identify purchases of newly issued securities, the CRSP Treasury data and the CMO data contain issuance dates. Additionally, the NAIC data include the date a security is purchased. From 2001 onward, the NAIC includes the purchase date, but for 1997 to 2000, only the purchase year is given. Using 2001 holdings data, we fill in purchase dates for 1997 to 2000 when possible. We have purchase dates for 75%, 62%, 48%, and 40% of CMO holdings for 2000, 1999, 1998, and 1997, respectively. If the purchase date is missing, we use the issuance quarter if the acquisition year matches the issuance year. Hence, our merged dataset includes the issuance date, the purchase date, and the amount that a given insurance company holds of a given bond at the end of the year. With this information, we build a quarterly dataset of purchases of newly issued securities. This quarterly panel dataset affords sharper timing with respect to key announcements. Examining newly issued securities is also more appropriate because the WAL in the CMO data is as of the origination.

Each quarter, we then aggregate the bond purchases of a given insurance company to calculate the total purchases of newly issued medium- and long-term USTs, PACs, and SEQs in the sample. We classify CMOs as medium-term if they have average lives at issuance of 2 to 10 years, and long-term if they have average lives of more than 10 years. This classification of medium- and long-term CMOs mimics the definition of UST notes and bonds, respectively. We use these purchases in Section 6 to analyze the impact of the elimination of the 30-year UST bond auction on the CMO holdings of life insurance companies.

To test the prediction in Hypothesis 1—that demand for long-term substitutes increases less among investors with more elastic demand for long-term investments—we construct a comparable dataset for property and casualty (P&C) insurers. As a placebo investor type, P&C insurers are characterized by shorter-dated liabilities and greater elasticity in their demand for long-term U.S. Treasuries (USTs). As in the case of life insurers, we merge NAIC Schedule D - Part 1 P&C bond portfolio data from 1997 to 2007 with our CRSP Treasury datat and CMO issuance data.

To test the Gap Filling Hypothesis (Hypothesis 2), we analyze our CMO issuance data and examine whether the issuance of long-term agency and corporate bonds increased during the period without 30-year UST bond auctions. We collect corporate and agency bond issuance data from the Datastream and Mergent-FISD databases. For agency bonds, we focus on benchmark bonds issued by Fannie Mae and Freddie Mac, which are non-redeemable and serve as a standard reference for other debt instruments in the fixed-income market. These bonds typically have larger issuance sizes, longer maturities, and high liquidity, making them particularly attractive to institutional investors.

For corporate bonds, we restrict the sample to USD-denominated corporate bond offerings by U.S.-domiciled firms from 1997 to 2007 that are non-redeemable, non-putable, non-convertible, non-exchangeable, fixed-rate debt. We focus on non-redeemable corporate bonds because redeemable bonds carry prepayment risk and are therefore not suitable substitutes for long-term USTs. Credit ratings closest to the issuance date are obtained from S&P, Moody's, Fitch, and Duff & Phelps. We present results for investment-grade offer-

ings rather than limiting the analysis to AAA corporate bonds due to the small number of AAA issuances. From 1997 to 2007, only 85 long-term AAA-rated bonds were issued, totaling $6.5 billion. Expanding the sample to include all investment-grade bonds, we identify 803 long-term issuances amounting to $140.5 billion. Badoer and James (2016) include redeemable corporate bonds; approximately 66% (62%) of AAA (investment-grade) issuances are redeemable.

As discussed in Section 6, we address the possibility that our results on Hypotheses 1 and 2 are influenced by concurrent shocks to unobservable variables unrelated to the supply of the 30-year UST bond. To account for this, we extend our primary dataset on CMO issuance and life insurers' fixed-income holdings—originally covering 1997 to 2007—to span from 1995 to 2023. This enables us to examine changes in life insurer purchases during placebo periods and to analyze the general relation between CMO and Treasury issuance over a broader range of economic cycles. For Fannie Mae and Freddie Mac CMOs, data through 2016 is sourced from Bloomberg, while Datastream provides information for 2017 to 2023. For Ginnie Mae CMOs, we use data from the Ginnie Mae website through 2022, supplemented by Datastream for 2023. Our expanded data on life insurer fixed-income holdings are also obtained from the NAIC.

To examine the Price Reaction Hypothesis (Hypothesis 3), we use our CRSP Treasury data and we also gather monthly PAC index returns from the ICE Bank of America - Merrill Lynch CMO Index database. These indices are available from the ICE Index Platform on the last trading day of each month during our sample period.[40] The data for PACs (CMOP and CMPZ indices) include market value, total return, effective yield, and effective duration of CMO portfolios grouped by effective duration. The effective yields and durations are calculated by the ICE Bank of America Merrill Lynch index provider using their model. The effective yields and durations of CMOs are calculated with a prepayment model that estimates variations in CMO cash flows due to changes in interest rates. Since price reactions to interest rate fluctuations are influenced by bond durations, we categorize medium- and long-duration PACs based on their effective duration for examining Hypothesis 3. We also gather data on SUPs (CMSZ), which we analyze in the Appendix Figure A4.

There are limitations: (1) we do not observe the underlying constituents of the indices, so the composition may change monthly, and (2) at longer maturities, the number of constituents is sparse. Specifically, the portfolio of PACs with a duration longer than that of the 10-year note (about eight years) has a median of 12 constituents.

A.4 Additional Evidence Supporting PBM Identification

Next, we perform several additional tests that take advantage of the heterogeneity in CMOs and life insurer characteristics to further support our identification of the PBM.

First, further supporting previous findings that life insurers demand long-term safe assets with a stable life, we exploit the fact that not all PACs have the same protection against prepayment. Specifically, there are PACs with different bands. For example, there are PACs with bands equal to 100% PSA - 300% PSA and PACs with bands of 120% PSA - 250% PSA. PACs with narrower bands are riskier because their cash flows are stable only within a

[40] https://www.ice.com/fixed-income-data-services/index-solutions/fixed-income-indices.

narrower prepayment band. PACs are often identified with an accompanying number. PACs with lower numbers (e.g., PAC-1) are safer because they have wider bands than PACs with higher numbers (e.g., PAC-2).

We therefore examine whether life insurers increased their purchases of long-term PAC-1 and PAC-2 relative to medium-term PAC-1 and PAC-2. To do so, we estimate a difference-in-differences specification similar to Equation 7. The first difference is the change in the principal amount of medium and long-term PAC-1s (PAC-2s) in insurance company portfolios during the *No Auction* period relative to the period with bond auctions. The second difference captures differences in this change in PAC-1s (PAC-2s) holdings during the *No Auction* period for long-term and medium-term PAC-1s (PAC-2s). In Table A5, Columns (1) and (3), we show that life insurers significantly increased purchases of PAC-1 tranche types during the *No Auction* period. And, in the *Post Period*, there is no difference in PAC-1 purchases relative to the period before the suspension. By contrast, Columns (2) and (4) show no change in purchases of PAC-2 tranche types in the *No Auction* period. These findings exploiting the degree of prepayment protection of PACs, along with the results in Table 3 that insurers do not increase purchases of SEQs but do increase purchases of long-term PACs, cleanly identify the PBM.

Second, our results in Table 3 showing that insurers substitute UST bonds with long-term PACs are not driven by the largest or smallest insurers. Instead, Table A6 Columns (1)-(2) and (4)-(5) show a significant increase in PAC purchases for insurers with ranks based on 1999 AUM of 1 to 75 and 76 to 150. Although the coefficients for insurers of ranks 151 to 250 are not statistically significant, the coefficients are positive and economically meaningful.

Figure A1: **UST Bond Auction Suspension & Collateral Supporting PAC Issuance.** This figure shows that the pass-through collateral supporting groups of tranches with PACs increased relative to the collateral supporting SEQs. The dependent variable is the difference in the aggregate value (in billions) of collateral backing PACs in quarter q and the aggregate collateral backing SEQs. The red (dashed) vertical lines denote the $\mathbb{1}(\text{No Auction})_q$ period from 2001 Q4 (30-year UST bond auction suspension) to 2005 Q4 (quarter prior to auction resumption).

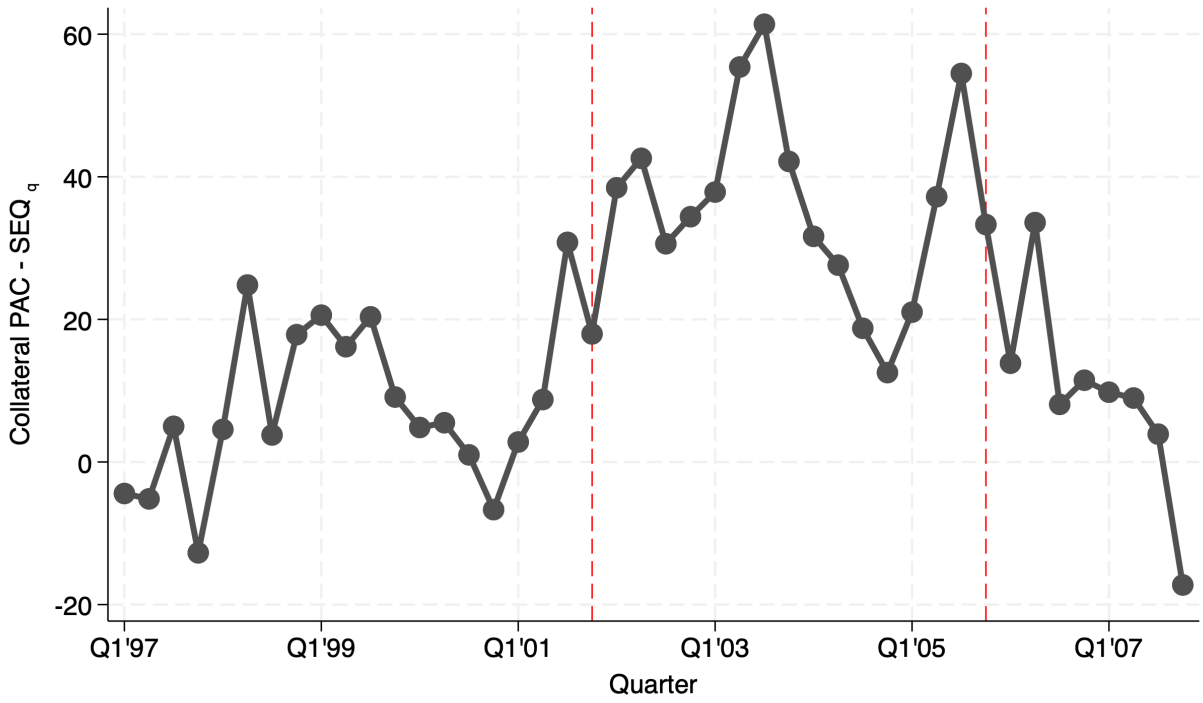


Figure A2: **Daily UST Returns & the Suspension Announcement.**
The figure shows the daily difference in returns for UST bonds (25-30 years maturity) and 10-year UST notes (9-10 years maturity). Daily returns are calculated as the price change plus accrued and paid interest, divided by the previous day's price plus accrued interest (TDRETNUA in CRSP). We calculate the principal-weighted average of daily returns for UST bonds and notes. Red circles mark key events: LTCM meltdown (Sept. 23, 1998), Gesler predicts 30-year UST loses benchmark status (Feb. 2, 2000), suspension announcement of 30-year UST auctions (Oct. 31, 2001), possible resumption announcement (May 4, 2005), confirmation of resumption (Aug. 3, 2005) and first auction after suspension (Feb. 9, 2006).

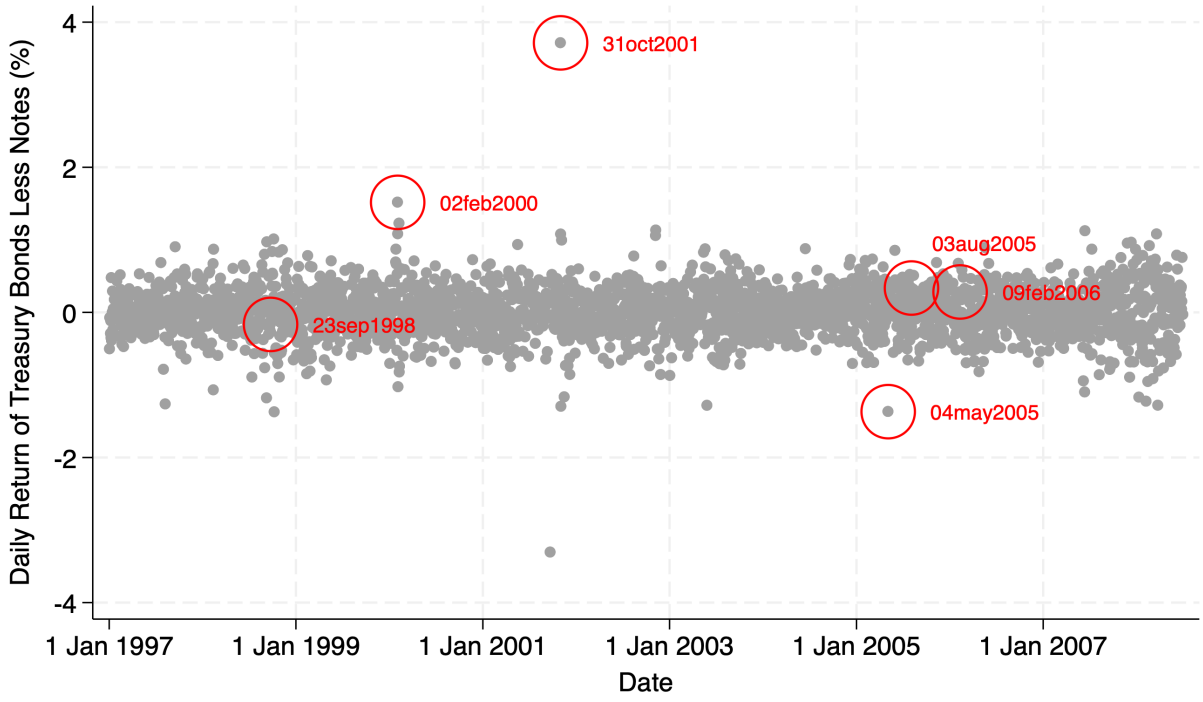
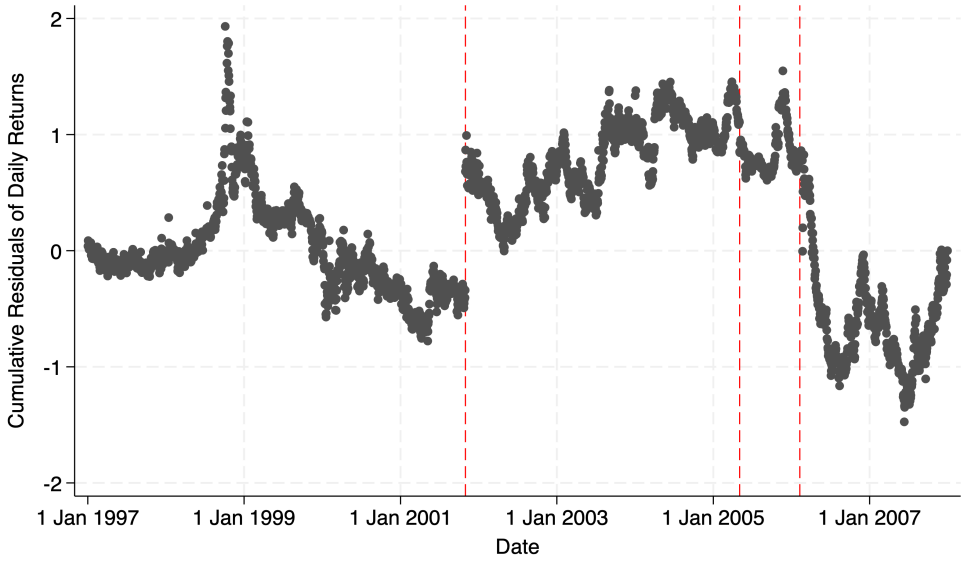
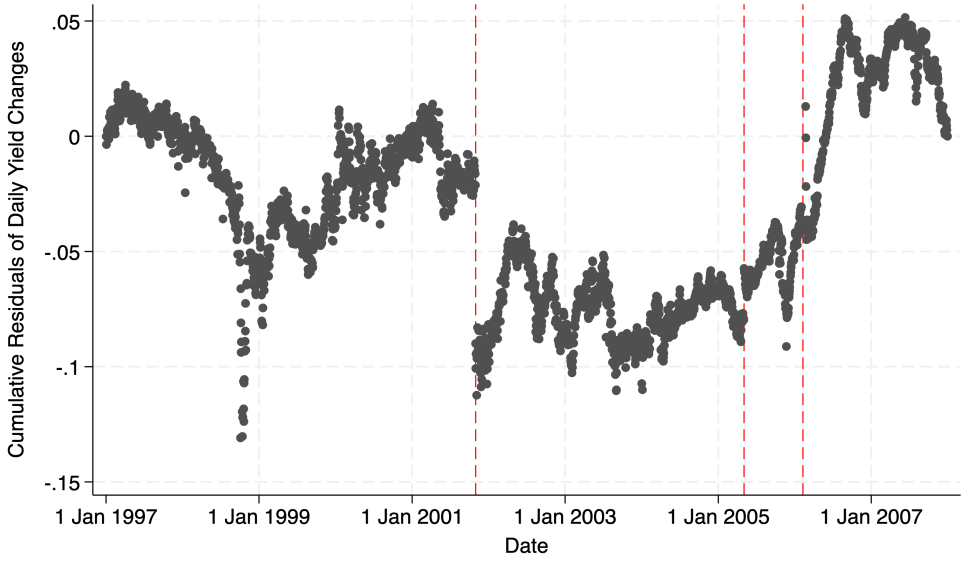


Figure A3: **Cumulative Residual Returns & Changes in Yields.**
To isolate the impact, we residualize the returns and yield changes of 30-year UST bonds relative to those of other maturities. Specifically, we regress the weighted average daily return and daily yield change of traded 30-year USTs (maturities between 25 and 30 years) on those of bonds with maturities of less than 1 year, 1–2 years, 2–3 years, 3–5 years, 5–7 years, 7–15 years, 15–20 years, and 20–25 years. We then use the regression residuals to compute cumulative returns and cumulative changes in yields. Panel A shows the cumulative residual daily return of the 30-year UST. Panel B shows the residual daily change in YTMs. Table A14 shows the regressions used to generate the residual returns and changes in YTM. Vertical red (dashed) lines mark key events: suspension announcement of 30-year UST auctions (Oct. 31, 2001), possible resumption announcement (May 4, 2005), and auction reintroducing the 30-year UST bond (Feb. 9, 2006).



(a) Cumulative residual daily 30-year UST returns



(b) Cumulative residual daily changes in 30-year UST YTM

Figure A4: **Monthly SUP Returns and the Suspension.**
The figure shows the monthly returns for agency SUP bonds. We circled Oct. 2001 (suspension of 30-year UST bond auctions) and May 2005 (possible resumption of UST bond auctions). Our identification of the PBM is independent of SUPs' price reactions. For instance, increased demand for SUPs cannot explain why life insurers bought more long-term PACs over medium-term PACs. Since PACs and SUPs are created together, we briefly consider SUP price scenarios. One scenario is a price drop due to the 30-year UST bond supply shock, as SUP holders capture the prepayment risk of additional PACs. Consistent with this scenario, Figure A4 shows a slight return decrease for agency SUPs (CMSZ index) following the 30-year UST bond auction suspension announcement. Another scenario is that SUP prices remain stable, allowing mortgage dealers to profit by selling PACs and SUPs above collateral prices. Data on mortgage dealers' profitability would clarify these scenarios. Testing these alternatives for SUP prices is beyond our PBM analysis, but could be explored in future research. During our sample period, SUP tranches have a 49bp higher effective yield than long-term PACs due to higher prepayment exposure.

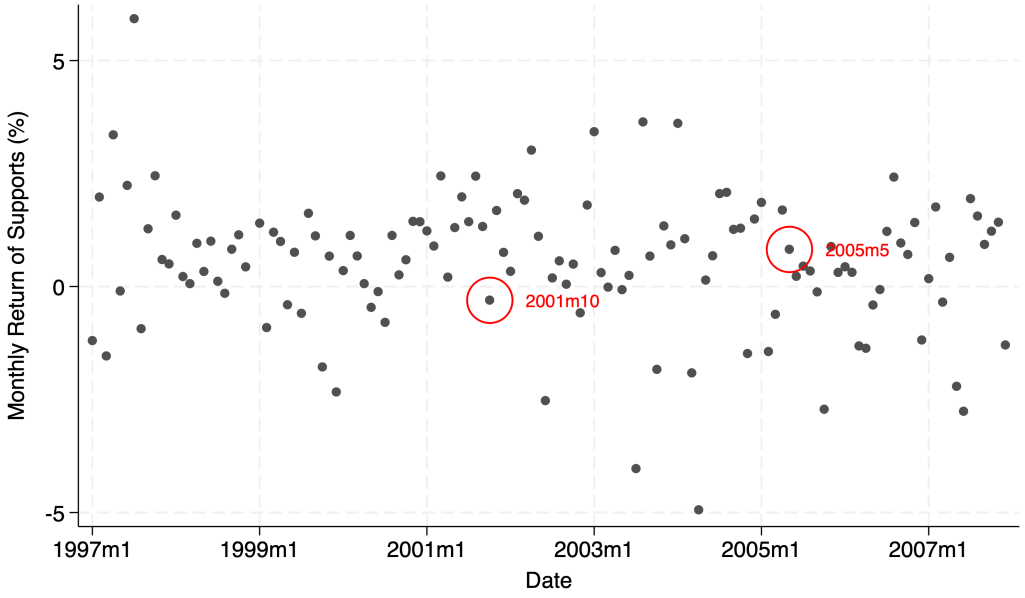


Figure A5: **Principal Cash Flows of a Mortgage Pass-through under Different Prepayment Speeds.**
This figure shows the principal cash flows of a 5% coupon pass-through security under different PSA scenarios. The initial principal is $100 million. The x-axis has the weighted average loan age (months) of the loans backing the mortgage pass-through. The PSA standard is a metric for prepayment speed scenarios, accounting for mortgage seasoning. It assumes an annual prepayment rate of 0.2% for one-month-old loans, increasing by 0.2% monthly until 6% at 30 months, then remaining constant. The 100% PSA scenario follows the PSA standard, 200% PSA is double, and 50% PSA is half. The figure is build with a $100 million unpaid principal at time zero.

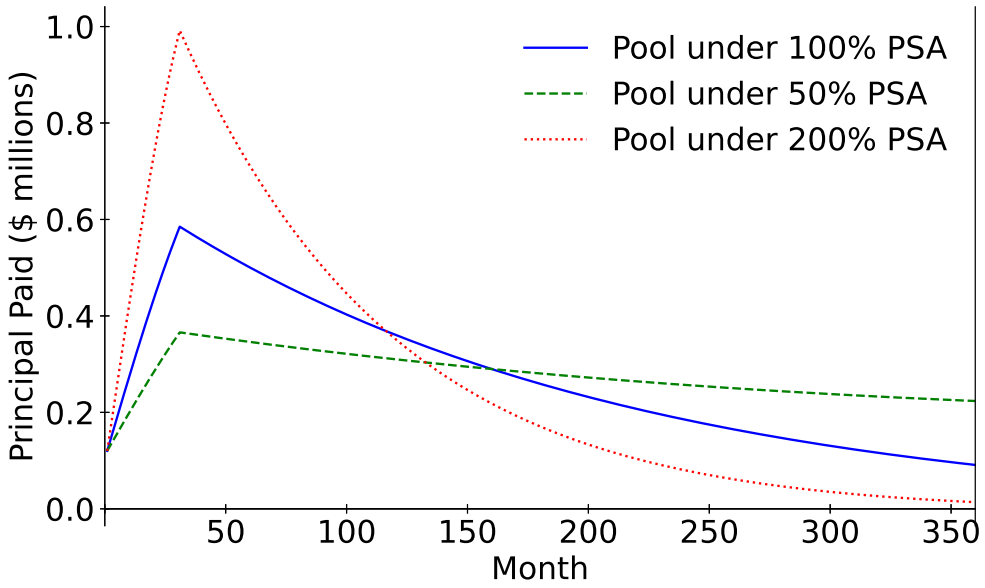
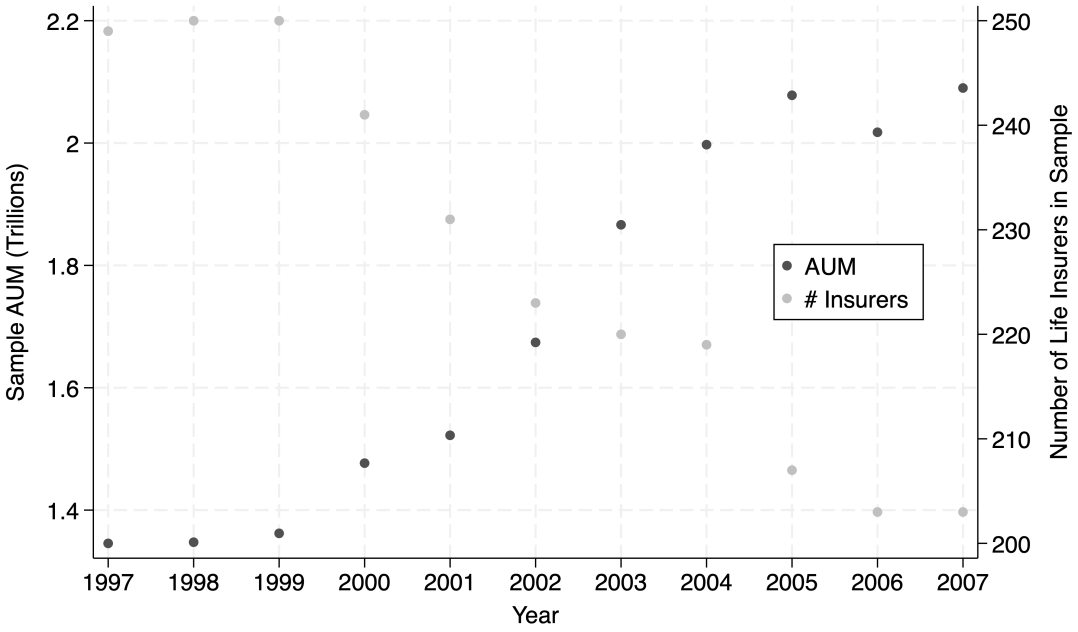


Figure A6: **Life Insurer AUM and Count by Year in the Sample.**
We sample the top 250 U.S. life insurers by fixed income portfolio size at the end of 1999. We plot their aggregate AUM from 1997 to 2007 and the number of insurers each year. The number of insurers decreases over time, reflecting national trends in life insurance (American Council of Life Insurers *Life Insurers Fact Book 2022*, Table 1.7 (ACLI, 2022)).



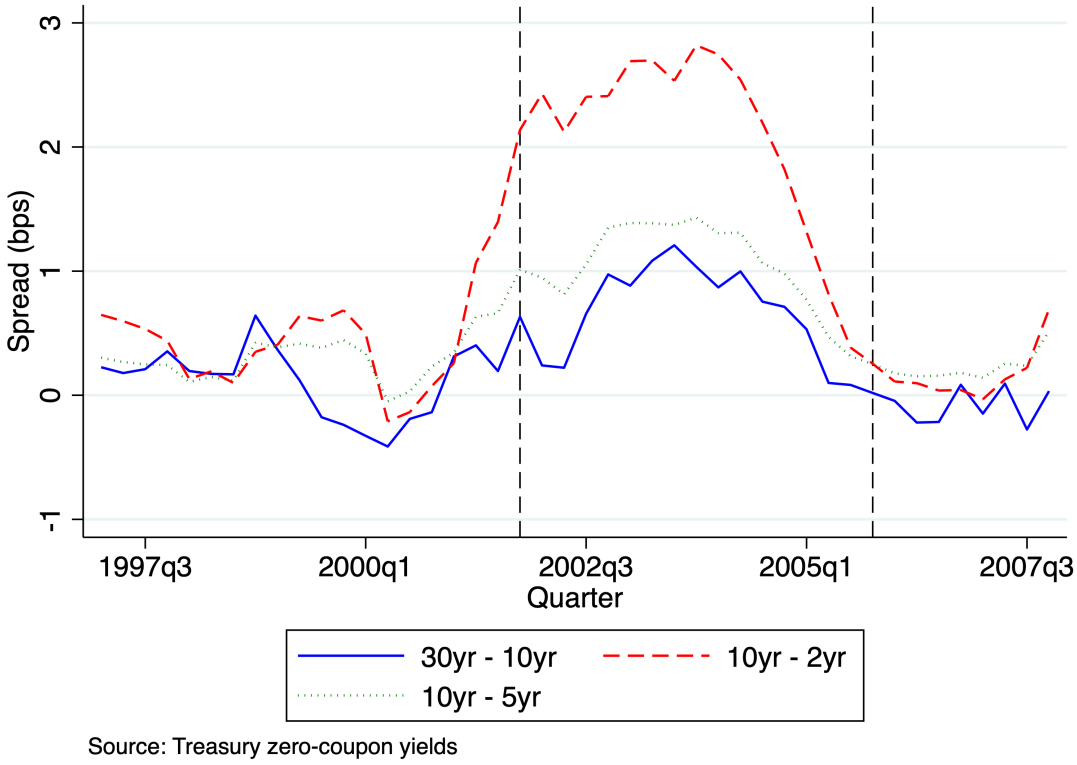
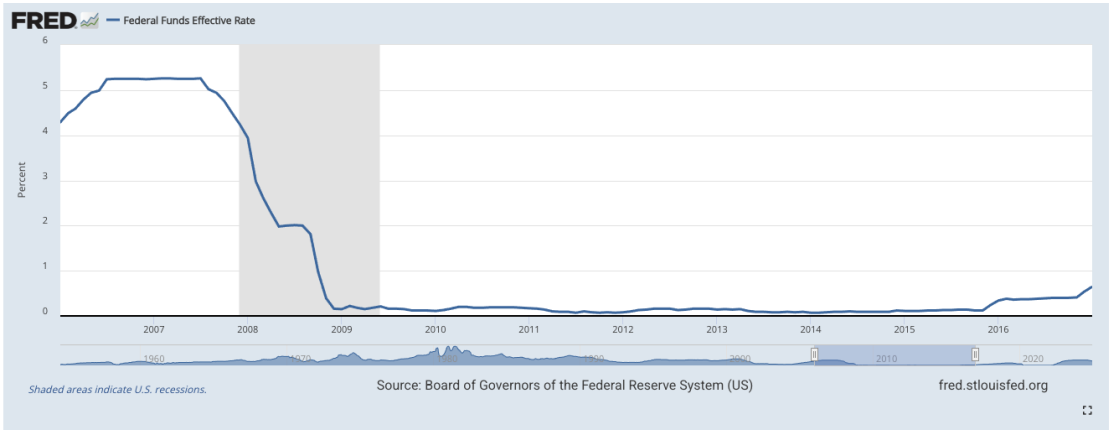
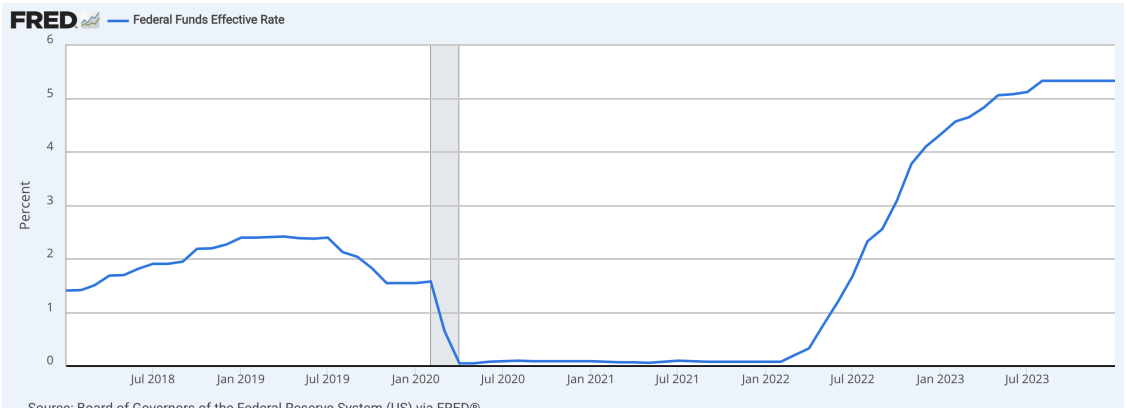


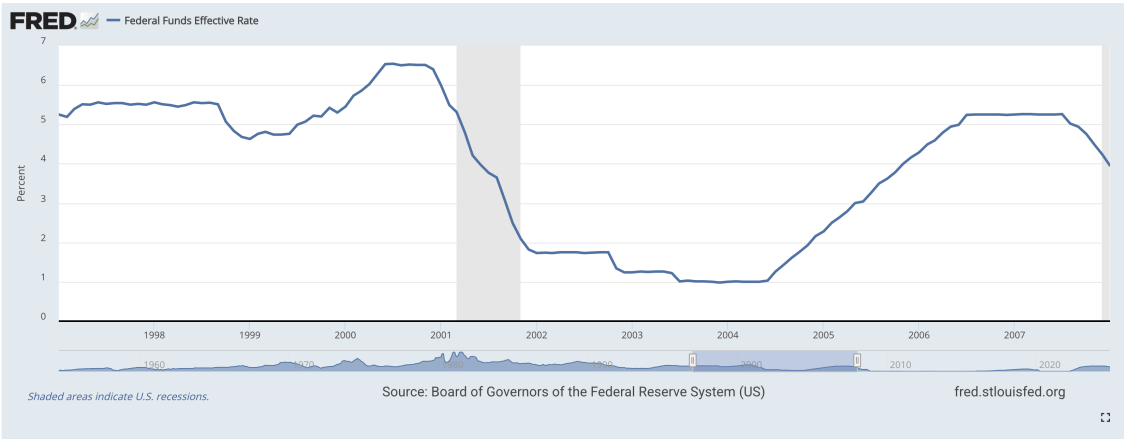
Figure A7: Treasury Yield Spreads: 1997-2007



(a) Fed Fund Rate during Placebo period #1: 2006-2016



(b) Fed Fund Rate during Placebo period #2: 2018-2023



(c) Fed Fund Rate during Main Sample period 1997-2007

Figure A8: Federal Funds Rate during different periods: (a) Placebo Period 1 (2006-2016), (b) Placebo Period 2 (2018-2023), and (c) Main Sample Period (1997-2007).

Table A1: Panel A shows the breakdown of life insurers' fixed income portfolios by type of investment in 1999. The sample is the 250 largest insurers by AUM in 1999 used in our main analysis. We use Datastream to classify cusip level holdings (fidbtype). Panel B shows the breakdown for 250 largest property and casualty insurers in 1999. Note that P&C insurers fall under IRC Section 832, which allows for prorated tax-exempt treatment on municipal bond interest. By contrast, life insurers fall under IRC Sections 801-818, which do not provide a comparable prorate rtion rule for municipal bond interest. As a result, life insurers are taxed on municiapl bond interest just like regular corporate bond interest.

Panel A: Life Insurers' Fixed Income Holdings by Type in 1999

	Par Value (Billion)	Proportion (%)	Cumulative Sum (%)
Corporate	543	54.2	54.2
Agency CMOs	74	7.4	61.6
60% PAC CMOs			
24% SEQ CMOs			
Government	67	6.7	68.3
Mortgage Pass Throughs	66	6.6	74.9
Residential CMOs	62	6.2	81.1
Commercial MBS	51	5.1	86.2
Agency	46	4.6	90.8

Panel B: P&C Insurers' Fixed Income Holdings by Type in 1999

	Par Value (Billion)	Proportion (%)	Cumulative Sum (%)
Municipal Bonds	160	41.72	41.72
Corporate	93	24.27	65.99
Government	51	13.36	79.35
Mortgage Pass Throughs	26	6.85	86.20
Agency CMOs	15	3.79	89.99
65% PAC CMOs			
20% SEQ CMOs			
Agency	11	2.75	92.74
Residential CMOs	9	2.44	95.17
Commercial MBS	6	1.45	96.63

Table A2: **Robustness of Table 3 to log transformations.** This table shows that the results in Table 3 are robust to log transformations addressing data skewness. In column (1), the dependent variable is log(1 + X), where X is the aggregate value (in millions) of purchases of newly issued medium-term and long-term PACs by insurance company j in quarter q. We aggregate purchases of medium-term and long-term PACs separately, resulting in two observations i per quarter q for insurer company j. Medium-term PACs have a weighted-average life (WAL) between 2 and 10 years, and long-term PACs have a WAL of more than 10 years. In column (2), we use a similar outcome variable for the maturity of newly-issued medium-term and long-term USTs purchased by life insurers. Medium-term USTs have a time-to-maturity between 2 and 10 years, and long-term USTs have a time-to-maturity of more than 10 years. In columns (3) and (4), we repeat columns (1) and (2) after scaling X by the dollar size of the insurer's fixed income portfolio at the end of year $y-1$. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term (i=1) securities and zero for medium-term (i=0) securities. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. We control for insurer j's purchases of newly issued medium-term (i=0) and long-term (i=1) sequential tranches in quarter q ($SEQ_{i,j,q}$) to account for time-varying firm-specific factors affecting insurer j's demand for medium- and long-term CMOs in general. We include insurance company fixed effects to control for fixed differences between insurers and quarter fixed effects to control for aggregate trends. Standard errors are double-clustered by quarter and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	$\ln(1+\text{PACs}_{i,j,y})$	$\ln(1+\text{UST}_{i,j,y})$	$\ln(1+\text{SEQs}_{i,j,y})$	$\ln(1+\frac{\text{PACs}_{i,j,y}}{\text{AUM}_{j,y-1}})$	$\ln(1+\frac{\text{UST}_{i,j,y}}{\text{AUM}_{j,y-1}})$	$\ln(1+\frac{\text{SEQs}_{i,j,y}}{\text{AUM}_{j,y-1}})$
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_q$	0.18***	-0.23**	-0.05	0.03***	-0.04*	-0.00
	(0.06)	(0.10)	(0.05)	(0.01)	(0.02)	(0.01)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q$	0.05	-0.03	-0.02	-0.00	0.00	-0.01
	(0.04)	(0.06)	(0.03)	(0.01)	(0.01)	(0.01)
$\mathbb{1}(\text{LT})_{i,j}$	0.03	-0.29***	0.10***	0.00	-0.05***	0.02***
	(0.02)	(0.05)	(0.03)	(0.00)	(0.01)	(0.00)
$\ln(1+\text{SEQs}_{i,j,q})\times 100$	0.25***					
	(0.03)					
$\ln(1+\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}}) \times 100$				0.26***		
				(0.03)		
Constant	0.19***	0.46***	0.25***	0.03***	0.07***	0.03***
	(0.02)	(0.02)	(0.01)	(0.00)	(0.00)	(0.00)
Firm FE	Yes	Yes	Yes	Yes		
Quarter FE	Yes	Yes	Yes	Yes		
% Adjusted R^2	24.28	25.77	24.92	14.56	13.97	11.22
# Insurers	250	250	250	250	250	250
# Quarters	44	44	44	44	44	44
# Observations	19960	19960	19960	19960	19960	19960

Table A3: **Robustness of Table 3 to Narrower Medium Term 5≤WAL≤10.** Figure A7 shows the yield spreads of medium- and long-term bonds behave more similarly when narrowing the definition of medium-term notes to 5 to 10 years, instead of 2 to 10 years. This table shows that the results in Table 3 are robust to this narrower definition of medium-term notes. In Column (1), the dependent variable is the aggregate value (in millions) of purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) PACs by insurer j in quarter q, resulting in two observations i per quarter q for insurer j. Medium-term PACs have a weighted-average life (WAL) between 5 and 10 years, and long-term PACs have a WAL of more than 10 years. In Column (2), we aggregate purchases of newly issued medium-term and long-term USTs, where a UST's WAL is its time to maturity. In Column (3), we aggregate purchases of newly issued medium-term and long-term Sequential CMOs (SEQs). In Columns (4) to (6), we repeat Columns (1) to (3) after scaling by the insurer's fixed income portfolio size at the end of year $y-1$. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term ($i = 1$) securities and zero for medium-term ($i = 0$) securities. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. We control for insurer j's purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) SEQs in quarter q ($SEQ_{i,j,q}$) to account for time-varying firm-specific factors affecting insurer j's demand for medium- and long-term CMOs. We include insurance company and quarter fixed effects to control for insurer-specific and aggregate trends. We double cluster standard errors by quarter and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	$\text{PACs}_{i,j,q}$	$\text{UST}_{i,j,q}$	$\text{SEQs}_{i,j,q}$	$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\frac{\text{UST}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_q$	7.15**	-9.90*	0.65	0.07***	-0.06*	0.00
	(2.96)	(5.68)	(0.87)	(0.02)	(0.03)	(0.01)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q$	0.21	-2.20	-0.04	-0.00	-0.01	-0.01
	(0.83)	(2.16)	(0.53)	(0.01)	(0.02)	(0.01)
$\mathbb{1}(\text{LT})_{i,j}$	0.03	-2.32***	1.94***	0.01	-0.04***	0.03***
	(0.69)	(0.80)	(0.64)	(0.01)	(0.01)	(0.01)
$\text{SEQs}_{i,j,q}$	0.61***					
	(0.20)					
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$				0.29***		
				(0.04)		
Constant	1.14	8.24***	1.75***	0.04***	0.08***	0.03***
	(0.86)	(0.93)	(0.41)	(0.01)	(0.01)	(0.00)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	22.44	11.83	21.15	12.58	10.64	9.96
# Insurers	250	250	250	250	250	250
# Quarters	44	44	44	44	44	44
# Observations	19960	19960	19960	19960	19960	19960

Table A4: **Repeating Table 3 with secondary market purchases**
This table replicates Table 3, incorporating secondary market purchases using annual data to account for purchases made after the initial acquisition date. The table again shows that life insurers purchased more long-term PACs relative to medium-term PACs during the suspension of 30-year UST bond auctions. When examining secondary market purchases, the periodicity of our data is a year (instead of a quarter) because insurers' position amounts are reported annually. By contrast, when examining new issuances, we can use the precise purchase date and issuance date to construct a quarterly panel of newly-issued bond purchases. In Column (1), the dependent variable is the aggregate value (in millions) of purchases of medium-term ($i = 0$) and long-term ($i = 1$) PACs by insurer j in year y, resulting in two observations i per year y for insurer j. Medium-term PACs have a weighted-average life (WAL) between 2 and 10 years, and long-term PACs have a WAL of more than 10 years. When examining the secondary market purchases of CMOs, we adjust the WAL at origination to the year of acquisition. In Column (2), we aggregate purchases of medium-term and long-term USTs, where a UST's WAL is its time to maturity. In Column (3), we aggregate purchases of medium-term and long-term Sequential CMOs (SEQs). In Columns (4) to (6), we repeat Columns (1) to (3) after scaling by the insurer's fixed income portfolio size at the end of year $y-1$. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term ($i = 1$) securities and zero for medium-term ($i = 0$) securities. $\mathbb{1}(\text{No Auction})_y$ equals one for years from 2002 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005. The Treasury resumed UST bond auctions in Feb. 2006. We control for insurer j's purchases of medium-term ($i = 0$) and long-term ($i = 1$) SEQs in year y ($SEQ_{i,j,y}$) to account for time-varying firm-specific factors affecting insurer j's demand for medium- and long-term CMOs. We include insurance company and year fixed effects to control for insurer-specific and aggregate trends. We double cluster standard errors by year and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	$\text{PACs}_{i,j,y}$	$\text{UST}_{i,j,y}$	$\text{SEQs}_{i,j,y}$	$\frac{\text{PACs}_{i,j,y}}{\text{AUM}_{j,y-1}}$	$\frac{\text{UST}_{i,j,y}}{\text{AUM}_{j,y-1}}$	$\frac{\text{SEQs}_{i,j,y}}{\text{AUM}_{j,y-1}}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_y$	30.74*	-34.53***	-9.16	0.24**	-0.36***	-0.06
	(16.38)	(9.03)	(5.92)	(0.10)	(0.10)	(0.05)
$\mathbb{1}(\text{LT})_{i,j}$	2.20	-21.77***	2.66	0.03	-0.32***	0.03**
	(1.71)	(5.29)	(1.64)	(0.03)	(0.06)	(0.01)
$\text{SEQs}_{i,j,y}$	0.72*					
	(0.38)					
$\frac{\text{SEQs}_{i,j,y}}{\text{AUM}_{j,y-1}} \times 100$				0.45***		
				(0.08)		
Constant	4.26	39.97***	11.36***	0.17***	0.51***	0.16***
	(6.38)	(3.40)	(1.42)	(0.03)	(0.02)	(0.01)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	26.67	39.49	30.72	21.35	21.69	20.35
# Insurers	250	250	250	250	250	250
# Years	11	11	11	11	11	11
# Observations	4990	4990	4990	4990	4990	4990

Table A5: **Heterogeneity in PAC Safety & Insurer's Purchases.**
This table uses PAC prepayment risk heterogeneity to show that life insurers preferred the safest PAC tranches. In Column (1), the dependent variable is the aggregate value (in millions) of purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) PAC-1 CMOs by insurance company j in quarter q, resulting in two observations i per quarter q for insurer j. Medium-term CMOs have a weighted average life (WAL) between 2 and 10 years, and long-term CMOs have a WAL of more than 10 years. In Column (2), we use the WAL of newly issued PAC-2 CMOs. PAC-1 tranches offer more prepayment risk protection than PAC-2 CMOs. In Columns (3) and (4), we repeat Columns (1) and (2) after scaling by the insurer's fixed income portfolio size at the end of year $y-1$. $\mathbb{1}(\text{LT})_{i,j}$ equals one for insurer j's long-term ($i = 1$) securities purchases and zero for medium-term ($i = 0$) purchases. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. We control for insurer j's purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) SEQs in quarter q ($SEQ_{i,j,q}$) to account for time-varying factors affecting insurer j's demand for medium- and long-term CMOs in general. We include insurer and quarter fixed effects to control for fixed differences between insurers and aggregate trends. The coefficients in Columns (1) and (3) differ from those in Columns (1) and (4) of Table 3 because Table A5 examines the subsample of CMO deals with multiple PAC types (e.g., PAC-1 and PAC-2). We double cluster standard errors by quarter and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	$\text{PAC-1}_{i,j,q}$	$\text{PAC-2}_{i,j,q}$	$\frac{\text{PAC-1}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\frac{\text{PAC-2}_{i,j,q}}{\text{AUM}_{j,y-1}}$
	(1)	(2)	(3)	(4)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_q$	5.85**	-0.08	0.05**	-0.00
	(2.78)	(0.06)	(0.02)	(0.00)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q$	0.23	-0.06	-0.01	-0.00
	(0.94)	(0.06)	(0.01)	(0.00)
$\mathbb{1}(\text{LT})_{i,j}$	0.23	-0.02	0.01	-0.00
	(0.48)	(0.02)	(0.01)	(0.00)
$\text{SEQs}_{i,j,q}$	0.42***	0.00		
	(0.14)	(0.00)		
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$			0.26***	0.00
			(0.04)	(0.00)
Constant	1.40*	0.07***	0.04***	0.00***
	(0.81)	(0.01)	(0.01)	(0.00)
Firm FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
% Adjusted R^2	24.31	5.14	11.78	3.62
# Insurers	250	250	250	250
# Quarters	44	44	44	44
# Observations	19960	19960	19960	19960

Table A6: **Halted UST Bond Auctions, PAC Purchases, & Insurer Size.**
This table shows that results in Table 3 Column (1) are robust to different samples of life insurers based on their 1999 AUM. The dependent variable is the aggregate value (in millions) of purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) PACs by insurance company j in quarter q, resulting in two observations i per quarter q for insurer j. Medium-term PACs have a weighted-average life (WAL) between 2 and 10 years at issuance, and long-term PACs have a WAL of more than 10 years. Columns (1), (2), and (3) include insurers with a 1999 AUM rank of 1-75, 76-150, and 151-250, respectively. Columns (4) to (6) scale the outcome variable and controls by the lagged AUM of the insurer. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term ($i = 1$) securities and zero for medium-term ($i = 0$) securities. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4 (Treasury resumed UST bond auctions in Feb. 2006). $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 onwards. We control for insurer j's purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) SEQs in quarter q ($SEQ_{i,j,q}$) to account for time-varying firm-specific factors affecting insurer j's demand for medium- and long-term CMOs in general. We include insurance company and quarter fixed effects to control for fixed differences between insurers and aggregate trends in PAC purchases. Standard errors are double-clustered by quarter and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	$\text{PACs}_{i,j,1}$			$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$		
Insurer Rank by AUM 1999	1-75	76-150	151-250	1-75	76-150	151-250
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{No Auction})_q$	17.20*	3.93*	0.44	0.07**	0.09**	0.02
	(10.05)	(2.10)	(0.51)	(0.03)	(0.04)	(0.02)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q$	0.62	0.37	-0.24	-0.03	0.02	-0.01
	(2.86)	(0.55)	(0.18)	(0.02)	(0.03)	(0.02)
$\mathbb{1}(\text{LT})_{i,j}$	0.72	-0.10	0.10	0.02*	-0.01	0.01
	(1.55)	(0.22)	(0.12)	(0.01)	(0.01)	(0.01)
$\text{SEQs}_{i,j,q}$	0.45***	0.40***	0.43**			
	(0.16)	(0.15)	(0.18)			
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$				0.29***	0.29***	0.30***
				(0.08)	(0.06)	(0.06)
Constant	3.58	1.27**	0.51***	0.03***	0.05***	0.05***
	(2.76)	(0.61)	(0.17)	(0.01)	(0.01)	(0.01)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	24.10	14.75	13.86	12.65	13.00	11.66
# Insurers	75	75	100	75	75	100
# Years	44	44	44	44	44	44
# Observations	6200	6056	7704	6200	6056	7704

Table A7: **PLACEBO: Interest Rate Drops in 2008 & 2020 Crises and Insurers' PAC Purchases**

This table shows no change in life insurers purchases of newly-issued long-term PACs relative to medium-term PACs after the fed fund rate fell quickly from 5% to 0% in the financial crisis (Placebo #1) and when the fed fund rate fell quickly in the covid crisis (Placebo #2). See Figure A8 for fed funds rate time series in the two placebo periods. In Columns (1) & (3), the dependent variable is the aggregate value (in millions) of purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) PACs by insurer j in quarter q, resulting in two observations i per quarter q for insurer j. Medium-term PACs have a weighted-average life (WAL) between 2 and 10 years, and long-term PACs have a WAL of more than 10 years. In Columns (2) & (4), we repeat scale purchases by the insurer's fixed income portfolio size at the end of year $y - 1$. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term ($i = 1$) securities and zero for medium-term ($i = 0$) securities. $\mathbb{1}(\text{Crisis})_q$ equals one for quarters from 2008 Q3 to 2012 Q4 (Placebo 1) and one for quarters from 2020 Q2 to 2022 Q4. $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2013 Q1 to 2016 Q4 (Placebo 1) and one for quarters from 2023 Q1 to 2023 Q4. We control for insurer j's purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) SEQs in quarter q ($SEQ_{i,j,q}$) to account for time-varying firm-specific factors affecting insurer j's demand for medium- and long-term CMOs. We include insurance company and quarter fixed effects to control for insurer-specific and aggregate trends. We double cluster standard errors by quarter and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Placebo #1: 2006-2016		Placebo #2: 2018-2023	
	$\text{PACs}_{i,j,q}$	$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$	$\text{PACs}_{i,j,q}$	$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$
	(1)	(2)	(3)	(4)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Crisis})_q$	0.955	0.011	-0.581	0.001
	(0.670)	(0.011)	(0.591)	(0.004)
$\mathbb{1}(\text{LT})_{i,j} \times \mathbb{1}(\text{Post Period})_q$	-0.699	-0.005	-0.436	0.000
	(0.527)	(0.009)	(0.610)	(0.005)
$\mathbb{1}(\text{LT})_{i,j}$	0.418	0.003	0.222	-0.006
	(0.433)	(0.009)	(0.605)	(0.004)
$\text{SEQs}_{i,j,q}$	0.287***		0.098**	
	(0.096)		(0.040)	
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$		0.114***		0.188*
		(0.033)		(0.098)
Constant	0.373	0.010***	0.444***	0.005***
	(0.324)	(0.002)	(0.147)	(0.001)
Firm FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
% Adjusted R^2	26.85	5.10	11.07	5.95
# Insurers	203	203	174	174
# Quarters	44	44	24	24
# Observations	16528	16528	8048	8048

Table A8: **Robustness of Table 4 to using % of UST offerings with WAL in excess of 10 years.**

This table demonstrates that as the proportion of USTs issued that are long-term decreases, life insurers purchase more long-term PACs relative to medium-term PACs and other CMOs with prepayment risk. $\%\ LT\ UST_q$ is the dollar proportion of all UST issuances that have a WAL exceeding 10 years in quarter q, using issuance amounts as weights. Maturities are measured from the issuance date. For reopened issuances, we calculate maturities from the reopening date. In columns (3) and (6), we instrument $\%\ LT\ UST_q$ with the ratio of total UST outstanding in quarter q to GDP in quarter q. The first stage F-statistics are both above 10,000, exceeding the Stock-Yogo critical value of 10, indicating that the instrument is not weak. We include insurance company and quarter fixed effects to control for insurer-specific and aggregate trends. We report standard errors clustered at the insurer and quarter levels. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively.

	$\text{PACs}_{i,j,q}$			$\frac{\text{PACs}_{i,j,q}}{\text{AUM}_{j,y-1}}$		
	OLS	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(\text{LT})_{i,j} \times$ % LT UST_q	-88.03***	-29.57**	-113.71***	-1.29***	-0.37*	-1.65***
	(30.44)	(12.18)	(32.33)	(0.48)	(0.22)	(0.53)
$\mathbb{1}(\text{LT})_{i,j}$	2.19***	0.77**	2.57***	0.03***	0.01	0.04***
	(0.75)	(0.33)	(0.77)	(0.01)	(0.01)	(0.01)
$\text{SEQs}_{i,j,q}$	0.32***	0.22***	0.32***			
	(0.06)	(0.05)	(0.06)			
$\frac{\text{SEQs}_{i,j,q}}{\text{AUM}_{j,y-1}} \times 100$				0.25***	0.22***	0.25***
				(0.03)	(0.05)	(0.03)
Excl. Suspension & Crisis	No	Yes	No	No	Yes	No
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	20.07	15.33	8.41	11.16	10.97	2.97
# Insurers	250	250	250	250	250	250
# Quarters	120	88	120	120	88	120
# Observations	48160	34936	48160	48160	34936	48160

Table A9: **UST Bond Auctions & Aggregate Collateral Tranched into PACs.** In Column (1), the dependent variable is the pass-through collateral amount (in billions), and in Column (2), it is its natural logarithm. The results show that pass-through collateral backing PAC tranches increased during the UST suspension period versus SEQs. The sample includes collateral supporting PACs or SEQs, not both. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. Standard errors are clustered at the quarter level, and quarter fixed effects are included, absorbing the standalone $\mathbb{1}(\text{No Auction})_q$ and $\mathbb{1}(\text{Post Period})_q$ variables. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Billions	Log
	(1)	(2)
$\mathbb{1}(\text{No Auction})_q \times \text{PAC}_i$	27.41***	0.44***
	(4.23)	(0.19)
$\mathbb{1}(\text{Post Period})_q \times \text{PAC}_i$	1.32	-0.08
	(5.42)	(0.30)
PAC_i	7.74***	0.44**
	(2.65)	(0.16)
Constant	20.39***	2.83***
	(0.96)	(0.05)
Quarter FE	Yes	Yes
% Adjusted R^2	83.6	69.8
# Observations	88	88

Table A10: **Halted UST Bond Auctions & Life Insurers' Corp./Agency Purchases.** This table shows that life insurers did not purchase more newly-issued long-term AAA corporate bonds, investment grade corporate bonds, or agency bonds relative to medium-term bonds during the suspension of 30-year UST bond auctions. We limit the sample to straight, fixed rate corporate and agency bonds. For corporate bonds, we exclude issuances by financial firms and foreign firms. In Columns (1), (3) & (5), the dependent variable is the aggregate value (in millions) of purchases of newly issued medium-term ($i = 0$) and long-term ($i = 1$) bonds by insurer j in quarter q, resulting in two observations i per quarter q for insurer j. Medium-term bonds have a weighted-average life (WAL) between 2 and 10 years, and long-term bonds have a WAL of more than 10 years. In Columns (2), (4) & (6), we scale purchases by the insurer's fixed income portfolio size at the end of year $y-1$. $\mathbb{1}(\text{LT})_{i,j}$ is an indicator variable equal to one for insurer j's aggregate purchases of long-term ($i = 1$) securities and zero for medium-term ($i = 0$) securities. $\mathbb{1}(\text{No Auction})_q$ equals one for quarters from 2001 Q4 (when the U.S. Treasury suspended 30-year UST bond auctions) to 2005 Q4. The Treasury resumed UST bond auctions in Feb. 2006, and $\mathbb{1}(\text{Post Period})_q$ equals one for quarters from 2006 Q1 to 2007 Q4. We include insurance company and quarter fixed effects to control for insurer-specific and aggregate trends. We double cluster standard errors by quarter and insurer. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Y=AAA Corporate$_{i,j,q}$		Y=IG Corporate$_{i,j,q}$		Y=Agency Bonds$_{i,j,q}$	
	Y	$\frac{Y}{\text{AUM}_{j,y-1}}$	Y	$\frac{Y}{\text{AUM}_{j,y-1}}$	Y	$\frac{Y}{\text{AUM}_{j,y-1}}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}(LT)_{i,j} \times \mathbb{1}(\text{No Auction})_q$	0.18	0.00	0.86	0.02	-1.30**	-0.02***
	(0.13)	(0.00)	(0.72)	(0.01)	(0.55)	(0.01)
$\mathbb{1}(LT)_{i,j} \times \mathbb{1}(\text{Post Period})_q$	0.13	0.00	1.42**	0.03**	0.27	0.00
	(0.12)	(0.00)	(0.69)	(0.01)	(0.35)	(0.01)
$\mathbb{1}(\text{LT})_{i,j}$	-0.01	-0.00	-1.40**	-0.03**	-0.30	-0.00
	(0.03)	(0.00)	(0.64)	(0.01)	(0.35)	(0.00)
Constant	0.04	0.00*	3.76***	0.08***	1.35***	0.02***
	(0.03)	(0.00)	(0.17)	(0.00)	(0.12)	(0.00)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
% Adjusted R^2	4.26	3.00	27.05	11.89	5.03	4.04
# Insurers	250	250	250	250	250	250
# Quarters	44	44	44	44	44	44
# Observations	19960	19960	19960	19960	19960	19960

Table A11: **More Long-Term PAC Issuance with Fewer Long-Term USTs, 1995–2023**

This table demonstrates that as the proportion of Treasury debt issuances that have WALs exceeding 10 years decreases, mortgage dealers create more long-term PACs relative to total long-term PACs and SEQs. In column (5), we take the natural logarithm of this ratio to examine elasticities. *% LT UST*$_q$ is the dollar proportion of all UST issuances that have a WAL exceeding 10 years in quarter q, using issuance amounts as weights. Maturities are measured from the issuance date. For reopened issuances, we calculate maturities from the reopening date. *FF Rate*$_q$ is the 1-month federal funds rate futures, while *FF Rate Spread*$_q$ is the difference between 9-month and 1-month federal funds rate futures, reflecting market expectations for mortgage refinancing. *Term Spread*$_q$ is the yield difference between 30-year and 1-year Treasury securities. *IG Credit Spr*$_q$ is the spread between Moody's Baa corporate bond yield and the 30-year Treasury yield, indicating credit risk. *Linear Trend*$_q$ captures time trends per quarter. *Refi Index*$_q$ is the Mortgage Bankers Association (MBA) Refinancing Index, normalized by dividing by 10,000 for easier interpretation. Business cycle controls include four leads and lags of an NBER recession indicator. In column (3), we exclude the suspension years 2002–2005 and the crisis years 2008–2010. In columns (4), we instrument *WAM UST*$_q$ using total UST outstanding relative to GDP. First-stage F-statistics (76.4) exceed the Stock-Yogo threshold of 10, confirming instrument strength. We report Newey-West standard errors with four-quarter lags to correct for autocorrelation and heteroskedasticity. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively.

	Y=LT PAC/(LT PAC+LT SEQ) Tranche Issuance$_q$				
	Y	Y	Y	Y	Ln(Y)
	OLS	OLS	OLS	IV	OLS
	(1)	(2)	(3)	(4)	(5)
% LT UST	-10.70***	-8.63***	-4.13*	-23.19***	
	(2.00)	(2.03)	(2.23)	(4.45)	
Ln(1+% LT UST)					-20.19***
					(7.64)
FF Rate		0.04*	0.00	0.06	0.44***
		(0.02)	(0.03)	(0.04)	(0.12)
FF Spread		0.04	0.04	0.11	0.18
		(0.05)	(0.06)	(0.08)	(0.22)
Term Spread		-0.02	0.01	-0.03	-0.28**
		(0.04)	(0.04)	(0.04)	(0.14)
IG Credit Spr		0.02	0.16**	0.03	0.09
		(0.05)	(0.07)	(0.05)	(0.15)
Linear Trend		-0.00***	-0.00*	-0.00	-0.03***
		(0.00)	(0.00)	(0.00)	(0.01)
Refi Index		0.35**	0.40	0.13	0.60
		(0.15)	(0.28)	(0.16)	(0.49)
Constant	0.57***	-3.07	0.09	-4.61	-38.65***
	(0.05)	(2.07)	(2.24)	(3.11)	(10.63)
No Suspension/Crisis	No	No	Yes	No	No
Bus. Cycle Ctrls	No	Yes	Yes	Yes	Yes
% Adjusted R^2	25.19	41.47	25.09	11.62	43.92
# Observations	116	116	84	116	116

Table A12: **Gap Filling through Total Collateral Allocation into PACs vs. SEQs, 1995–2023.**

This table shows that as Treasury debt issuance duration shortens, mortgage dealers allocate more pass-through collateral to safer long-term PAC CMOs instead of long-term SEQ tranches. The dependent variable is the ratio of long-term PAC tranches to total long-term PAC and SEQ issuances. In columns (5) and (10), we take the natural logarithm of this ratio to examine elasticities. *WAM UST*$_q$ is the weighted average maturity of Treasury issuances per quarter, weighted by issuance amounts. Maturities are measured from the issuance or reopening date. *% LT UST*$_q$ is the share of quarterly Treasury issuances exceeding 10 years. In columns (5) and (10), we examine the natural log of WAM and % LT UST. *FF Rate*$_q$ is the 1-month federal funds rate futures, while *FF Rate Spread*$_q$ is the difference between 9-month and 1-month federal funds rate futures, reflecting market expectations for mortgage refinancing. *Term Spread*$_q$ is the yield difference between 30-year and 1-year Treasury securities. *IG Credit Spr*$_q$ is the spread between Moody's Baa corporate bond yield and the 30-year Treasury yield, indicating credit risk. *Linear Trend*$_q$ captures time trends per quarter. *Refi Index*$_q$ is the Mortgage Bankers Association (MBA) Refinancing Index, normalized by dividing by 10,000 for easier interpretation. Business cycle controls include four leads and lags of an NBER recession indicator. In columns (3) and (8), we exclude the suspension years 2002–2005 and the crisis years 2008–2010. In columns (4) and (9), we instrument *WAM UST*$_q$ and *% LT UST*$_q$ using total UST outstanding relative to GDP. First-stage F-statistics (76.4 and 65.4) exceed the Stock-Yogo threshold of 10, confirming instrument strength. We report Newey-West standard errors with four-quarter lags to correct for autocorrelation and heteroskedasticity. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively.

	Y=PAC/SEQ Collateral Issuance$_q$									
	Y	Y	Y	Y	Ln(Y)	Y	Y	Y	Y	Ln(Y)
	OLS	OLS	OLS	IV	OLS	OLS	OLS	OLS	IV	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
WAM UST	-0.07*	-0.11***	-0.15***	-0.21***						
	(0.04)	(0.03)	(0.06)	(0.07)						
Ln(1+WAM UST)					-0.24*					
					(0.14)					
% LT UST						-4.73***	-4.28***	-3.20	-10.13***	
						(1.71)	(1.57)	(2.48)	(3.46)	
Ln(1+% LT UST)										-6.97
										(6.05)
FF Rate		0.10***	0.10***	0.12***	0.31***		0.09***	0.08***	0.10***	0.29***
		(0.02)	(0.02)	(0.03)	(0.07)		(0.02)	(0.02)	(0.03)	(0.07)
FF Spread		0.08	0.04	0.12	0.19		0.07	0.04	0.10	0.16
		(0.06)	(0.08)	(0.07)	(0.14)		(0.06)	(0.08)	(0.07)	(0.13)
Term Spread		-0.08***	-0.05*	-0.08**	-0.24***		-0.08***	-0.05**	-0.08***	-0.23***
		(0.03)	(0.03)	(0.03)	(0.07)		(0.03)	(0.03)	(0.03)	(0.07)
IG Credit Spr		-0.03	0.02	-0.02	-0.09		-0.05	0.03	-0.04	-0.11
		(0.03)	(0.06)	(0.03)	(0.07)		(0.03)	(0.06)	(0.04)	(0.07)
Linear Trend		-0.00***	-0.01***	-0.00***	-0.02***		-0.00***	-0.00***	-0.00**	-0.01***
		(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
Refi Index		0.08	0.29	-0.05	0.22		0.17	0.31	0.08	0.36
		(0.12)	(0.19)	(0.14)	(0.24)		(0.12)	(0.21)	(0.14)	(0.23)
Constant	0.65***	-8.00***	-7.57***	-9.24***	-27.42***	0.61***	-7.05***	-5.94***	-7.67***	-25.91***
	(0.07)	(2.06)	(1.68)	(2.62)	(6.16)	(0.04)	(1.97)	(1.63)	(2.45)	(6.13)
No Suspension/Crisis	No	No	Yes	No	No	No	No	Yes	No	No
Bus. Cycle Ctrls	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
% Adjusted R^2	3.54	31.65	24.24	26.22	31.31	8.53	29.49	21.93	20.56	30.64
# Observations	116	116	84	116	116	116	116	84	116	116

Table A13: **Relationship Between Long-Term PAC Bond Returns and 30-Year UST Returns**

This table presents the estimated relationship between the weighted average monthly return of planned amortization class (PAC) bonds with a duration of 9 or more years and the monthly return of the on-the-run 30-year U.S. Treasury (UST) bond. The dependent variable is the return of long-term PAC bonds, which have a longer duration than the 10-year UST. Sample period is 1997 to 2007; however, there are five months with missing long-term PAC bond returns. Standard errors are robust to heteroskedasticity. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Long-Term PAC Bond Return	
	(1)	(2)
UST Bond Ret	0.77***	0.77***
	(0.07)	(0.05)
UST Bond Ret^2		-0.02*
		(0.01)
Constant	0.33**	0.52***
	(0.15)	(0.15)
% Adjusted R^2	68.45	69.60
# Observations	127	127

Table A14: **Model for Residual Returns & Changes in Yields**
The dependent variable in Column (1) is the weighted average daily return (*TDRETNUA*) of USTs with 25-30 years to maturity. We weight returns by the amount outstanding of a security. We separately control for the weighted average daily returns of USTs with maturities less than 1 year, in 1-2 years, in 2-3 years, in 3-5 years, in 5-7 years, in 7-15 years, in 15-20 years, and in 20-25 years. In Column (2), the dependent variable is the weighted average daily change in the YTM (*TDYTM*) of USTs with 25-30 years to maturity. The sample period is Jan. 1, 1997 to Dec. 31, 2007. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	30-Year USTs	
	Ret_d	dYTM_d
	(1)	(2)
Ret_d (mat. 0-1yr)	0.2103	
	(0.1448)	
Ret_d (mat. 1-2yr)	0.0144	
	(0.0792)	
Ret_d (mat. 2-3yr)	-0.1964*	
	(0.1187)	
Ret_d (mat. 3-5yr)	-0.0582	
	(0.1361)	
Ret_d (mat. 5-7yr)	0.1333**	
	(0.0566)	
Ret_d (mat. 7-15yr)	-0.0656	
	(0.0449)	
Ret_d (mat. 15-20yr)	-0.2149***	
	(0.0533)	
Ret_d (mat. 20-25yr)	1.3254***	
	(0.0505)	
ΔYTM_d (mat. 0-1yr)		-0.0003
		(0.0004)
ΔYTM_d (mat. 1-2yr)		-0.0009
		(0.0060)
ΔYTM_d (mat. 2-3yr)		-0.0388*
		(0.0213)
ΔYTM_d (mat. 3-5yr)		0.0231
		(0.0393)
ΔYTM_d (mat. 5-7yr)		-0.0401*
		(0.0213)
ΔYTM_d (mat. 7-15yr)		0.0526**
		(0.0248)
ΔYTM_d (mat. 15-20yr)		-0.1422***
		(0.0369)
ΔYTM_d (mat. 20-25yr)		1.1167***
		(0.0410)
Constant	-0.0041**	0.0001
	(0.0020)	(0.0001)
% Adjusted R^2	98.85	99.02
# Observations	2744	2744